THE COMPLETION OF THE HUDSON RIVER TUNNELS.

SCIENTIFIC AMERICAN SUPPLEMENT. No. 1678

Entered at the Post Office of New York, N. Y., as Second Class Matter.

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Published weekly by Munn & Co. at 361 Broadway, New York.

Charles Allen Munn, President, 361 Broadway, New York.
Frederick Converse Beach, Sec'y and Treas., 361 Broadway, New York

Scientific American, established 1845.
Scientific American Supplement, Vol. LXV., No. 1678.

NEW YORK, FEBRUARY 29, 1908.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

The trains from Jersey City will enter Manhattan by the tube shown in the foreground. The single track will diverge into five tracks, which will swing to the left and enter a six-platform station below the large building shown in the background. This building, 22 stories high, will house 20,000 people. Trains return to Jersey City by the tunnel shown at the left of building.

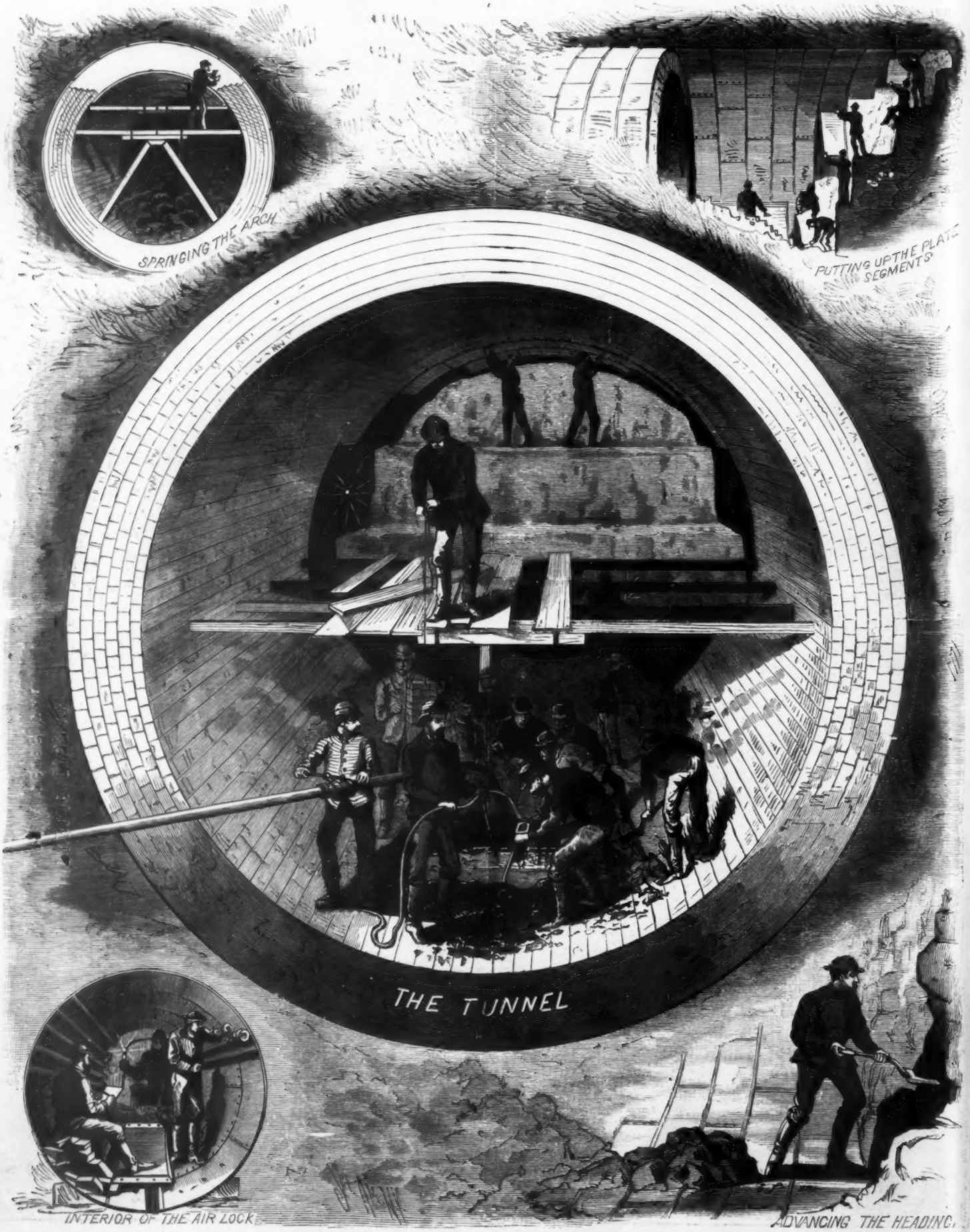
THE OPENING OF THE HUDSON RIVER TUNNELS.

THE OPENING OF THE HUDSON RIVER TUNNELS.

THE COMPLETION OF A GIGANTIC TASK.

On February 25 there were opened with appropriate ceremonies the twin tunnels from 15th Street, Jersey City, to Morton Street, New York, which form the first section of the important system of tunnels designed to facilitate travel between Jersey City and New York. Two trains, carrying respectively Governor Hughes of New York, and Governor Fort of New Jersey, started from New York and Jersey City, and met beneath the State line at the center of the Hudson. Here the governors shook hands from the front platforms of their respective trains; and thus was this great work placed at the service of the public.

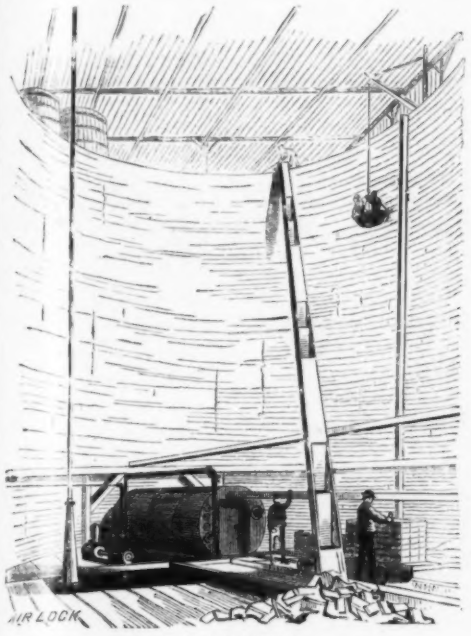
It was inevitable that with the growth of New York and Jersey City during the latter part of the nineteenth century, an effort should be made to provide some quicker and more reliable means of crossing the Hudson River than by the ferry-boat. Although the system of ferries which has been organized on the



THE GREAT TUNNEL UNDER THE HUDSON RIVER BETWEEN NEW YORK AND NEW JERSEY, SHOWING THE METHOD OF CONSTRUCTION ADOPTED WHEN WORK WAS STARTED IN 1874.

THE OPENING OF THE HUDSON RIVER TUNNELS.

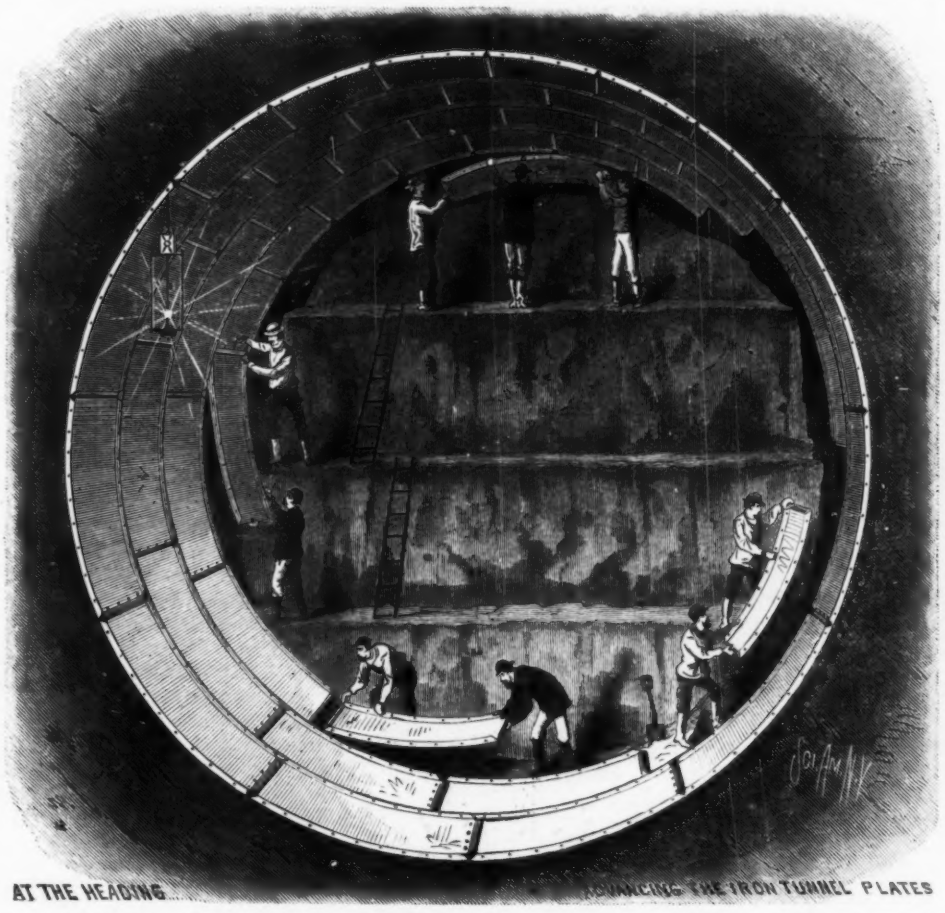
Hudson is upon the whole highly efficient, and is, indeed, to-day without a parallel in any part of the world, there are seasons of the year when fog and river ice are so prevalent that the ferries are liable to be seriously interrupted. The limited area of Manhattan Island rendered it necessary, as the city grew by leaps and bounds, for a large and increasing proportion of its population to seek homes elsewhere than on the island, and hence there has been a phenomenal development of the outlying suburbs in Long Island, the Bronx, and New Jersey. In the case of New Jersey, the call for better means of intercommunication was rendered doubly strong by the fact that four important railroad systems, including that of the Pennsylvania



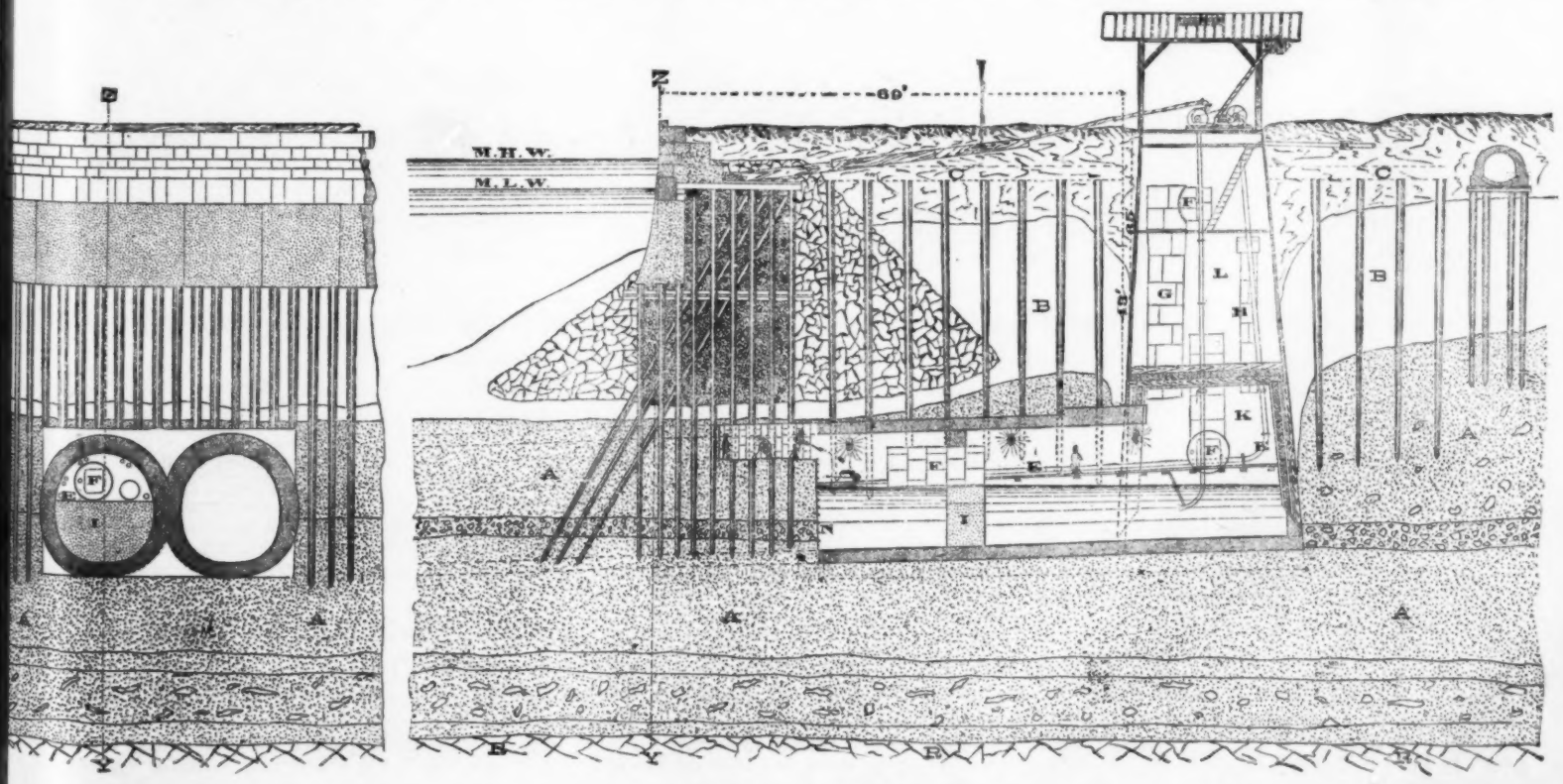
THE AIR LOCK.

Railroad, have their termini in Jersey City. Hitherto both the suburban and the long-distance passengers over these important railways have been obliged to transfer to the ferries, which all of them, a few years ago, and some of them even to-day, land their passengers at inconvenient points on Manhattan, from which a tramp through the crowded streets is necessary to reach the north and south bound elevated and trolley lines. Of the two methods of spanning the Hudson River by bridge or by tunnel, the latter was the first to take active form. As far back as the year 1874, an attempt was made to excavate the first tunnel. It was in that year that Mr. DeWitt Clinton Haskin, who had been prominent in the construction of the Union Pacific Railway, commenced the work of driving a tunnel beneath the Hudson River from the Jersey side.

Two shafts were sunk, one on 15th Street, Jersey City, about 100 feet back from the bulkhead line of the river; and the other near the bulkhead line on the New York side, at the foot of Morton Street. The distance between the two shafts was about 5,500 feet. The shaft in Jersey City terminated in a working chamber, from which the headings of the two parallel tunnels were started on a down grade of 2 feet in 100 toward their deepest level, which was planned to be at a point about 500 feet from the Jersey shore, where the tunnel would intersect the point of a ridge of rock. The profile of the tunnel was so arranged that at no point under the river was the top of the tunnel to be less than 20 feet below the river bed. The tunnel was constructed by the use of compressed air, but without the now well-known shield method construction, Mr. Haskins believing that the air pressure would prove sufficient to hold up the silt of the river bed until the brick lining of the tunnel, which was 2½ feet in thickness, was advanced in place. The method of excavating the tunnels was first to dig out the material for a certain distance ahead of the completed brickwork, and then line the silt with a covering of thin steel plates 3/16 of an inch in thickness, laid by hand, as shown in our illustrations. The 2½ feet of brick lining was then built in place. So long as the silt was of the right consistency, and of sufficient thickness to resist the escape of the air, the work progressed favorably; but when the tunnel reached a point under the river where the depth of the silt decreased, there was much trouble from blowouts and the consequent inrush of water. To meet this difficulty, it was decided to drive a pilot tunnel into the heading. This consisted of an iron tube 5 feet in diameter, which projected axially from the center of the face



THE EARLY METHOD OF BUILDING THE HUDSON RIVER TUNNEL—LAYING THE IRON PLATES IN ADVANCE OF THE 2½-FOOT BRICK LINING.



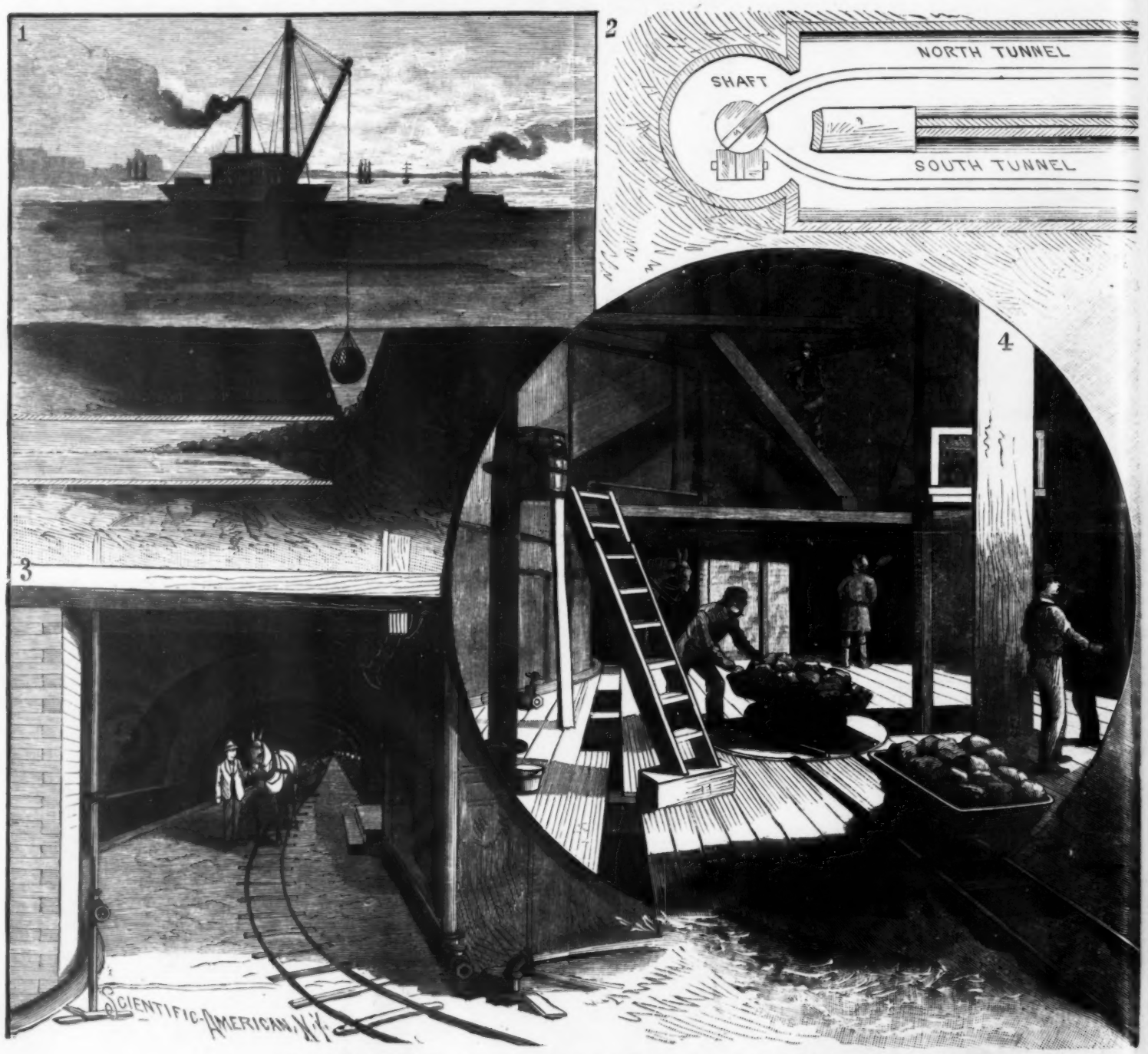
THE JERSEY CITY TERMINAL SHAFT OF THE HUDSON RIVER TUNNEL IN 1874–5.

A, A. Sand. B, B. Dock mud. C, C. Filling. E, E. Air pipe. F, F. Air locks. G. Main shaft. H. Timber lock. I, I. Concrete bulkhead for air lock. K. Caisson. L. Coffer dam. N. Iron bulkhead. R, R. Bed rock.

of the tunnel, and was driven for a certain distance ahead into the silt. The tube was used as a center, from which struts were carried out radially to hold the silt in place. The work proceeded more satisfactorily by this method; but on July 21, 1880, there was a blowout, which resulted in such a sudden inrush of water, that the air lock, which was situated a short distance only back from the head of the tunnel, became jammed, and twenty of the workmen were caught before they could get through the lock, and drowned. In spite of these discouragements, the work was carried on with more or less intermission until the year 1882, when, with 2,000 feet of the north tunnel completed, the company suspended operations.

The next attempt to prosecute the work took place in 1890, when an English company was organized, with the material is brought within the tunnel conveniently for loading on cars and carrying away. Furthermore, the danger of blowouts is greatly reduced, and when they occur, they are much more readily handled than was possible under the old method. Under the English company the work was pushed forward until about 4,000 feet of the north tunnel had been completed. Then for want of funds the project was once more abandoned.

Nothing more was done until the year 1892, when, chiefly through the efforts of Mr. W. C. McAdoo, a strong company was formed to take hold of the abandoned tunnel and push it through to the Manhattan side. The north tunnel was pumped out, and under Mr. Charles M. Jacobs as chief engineer, the remaining 1,400 feet was completed. The work of Mr. Jacobs of the tunnel through rock and the roof through silt. To meet these conditions, it was found necessary to build an apron out in front of the shield, which would protect the workmen from the silt above. This apron, as shown in one of our illustrations, extended from side to side of the tunnel shield near its center line, and projected forward about 6 feet. It was built of ¾-inch steel plates, laid on brackets formed of 12-inch I-beams. This apron enabled the workmen to attack the rock without fear of being smothered by an avalanche of the soft silt above. Even with this protection the work was not without danger, as the rock varied in height from 1 to 16 feet. Fortunately, no casualties resulted, and the shield was slowly but steadily forced through the rock reef. With this danger past, the remainder of the work was comparatively simple, and



1. Closing hole in tunnel. 2. Plan of shaft and tunnel openings. 3. The tunnel entrance. 4. View at foot of west shaft.

THE FIRST ATTEMPT TO CONSTRUCT THE HUDSON RIVER TUNNEL.

THE OPENING OF THE HUDSON RIVER TUNNELS.

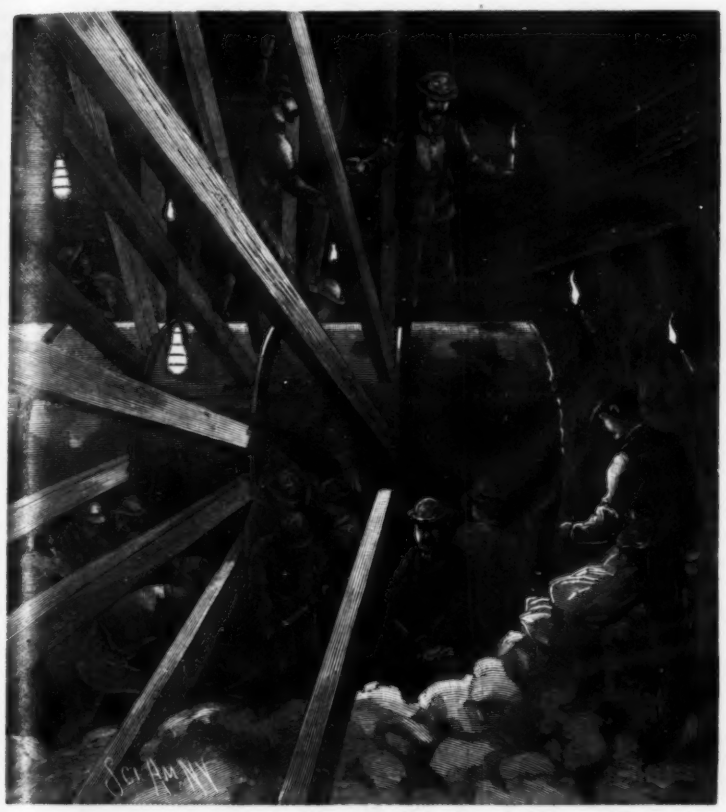
Sir John Fowler and Sir Benjamin Baker, who designed and built the Forth Bridge, as consulting engineers. The English engineers introduced the use of the Greathead shield, the method of operation of which is now very familiar. This shield is nothing more nor less than a short section of steel tube, of a diameter slightly larger than that of the finished tunnel, which is provided with a hard steel cutting edge at its forward end, back of which is an airtight bulkhead or diaphragm. This shield is pushed forward ahead of the completed tunnel by means of a large number of hydraulic rams, disposed around its circumference between the shield and the front of the completed tunnel. Doors are provided in the diaphragm through which the silt, as the shield is pushed forward, passes into the interior of the tunnel. It will thus be seen that the shield took the place of the earlier system of separate iron plates laid by hand, temporarily to hold back the material; also, it has the great advantage that in accomplishing that which had twice before been attempted and abandoned is deserving of highest praise, particularly in view of the fact that difficulties were met and successfully overcome which the other companies did not encounter, and which, in fact, the engineering world has never before been called upon to master. The work had progressed only a few hundred feet when rock was encountered in the lower part of the tunnel. The excavating shield in use, the one that the English company had installed, was designed to be forced through silt, and it would merely have crumpled into a shapeless mass if it had been driven against this rock barrier. It was necessary, therefore, for the workmen to advance beyond the cutting edge of the shield, and blast out this rock before moving the shield forward. If the rock had covered the entire face of the shield, this would have been a comparatively easy matter; but the engineers were confronted by the unique problem of driving the floor the tunnel was rapidly pushed on to the New York heading.

As the work advanced, the course of the tunnel was carefully plotted out, and the excavating shield was steered by increased pressure in one or another of the hydraulic jacks, in order that it should be brought into perfect register with the brick lining of the New York heading at the point of juncture. So careful were these calculations, that when the shield met this heading, the lateral alinement was found to be almost perfect; but vertically, an error of a few inches was made. This break is temporarily sealed with blocks of wood driven into the silt above the shield.

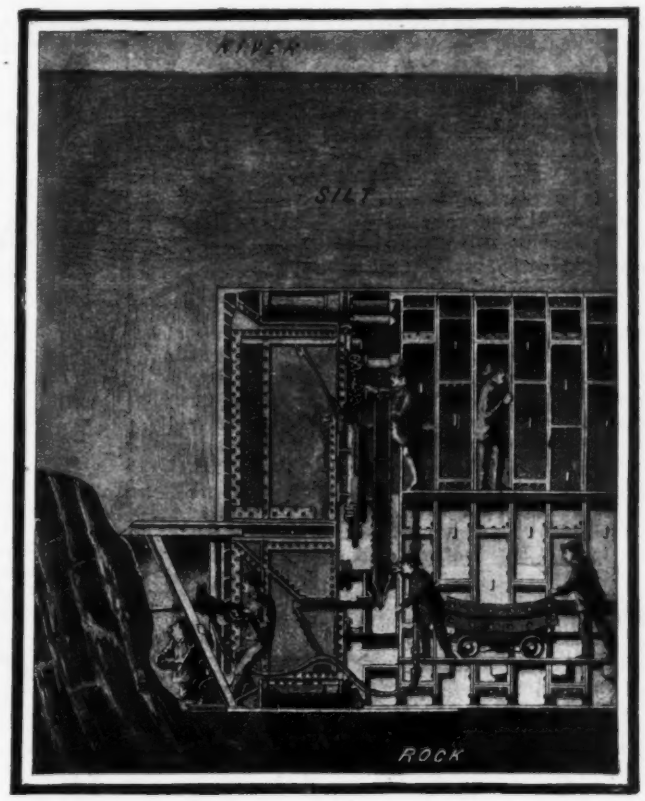
While the shield was being operated by the English company, it was noticed that instead of remaining stationary on its axis, it was gradually turning clockwise as viewed from the front. Every effort was made to stop this movement; but it continued, until when it had traversed 3,400 feet of silt, it presented the ap-

pearance illustrated, with the vertical plates lying almost horizontal. This curious action was probably due to a slight deflection of the plates in front of the diaphragm of the shield, which tended to turn the shield through an imperceptible angle every time it was jacked forward, and these slight deflections gradually accumulated until they became quite noticeable. The tunnel has an internal diameter of 18 feet 1½ inches, and is lined with cast-iron segments 1½ inches thick, braced with webs and formed with inwardly-projecting flanges, which provide means for firmly bolting the sections together. The shield was ultimately dismantled, and the cast-iron sheathing or lining run out to join the brick lining of the old heading. The shell of the shield, however, was not removed, and was buried behind the cast-iron lining, a final sacrifice to the work it has served so long and faithfully.

A combined elevator and air lock was used at the head of the New York shaft. The elevator shaft ended in an air lock at its upper end, and the circular platform of the cage, when in its highest position, completely closed the mouth of the shaft, and formed the bottom of the air lock. As the compressed air was released from the lock, this platform was forced snugly in place, making an air-tight closure. The cable by which the elevator was suspended passed through the top of the air lock, and to prevent leakage of the compressed air was incased in a long stuffing box. The movement of the cable through this was so slow as not to seriously wear the packing.

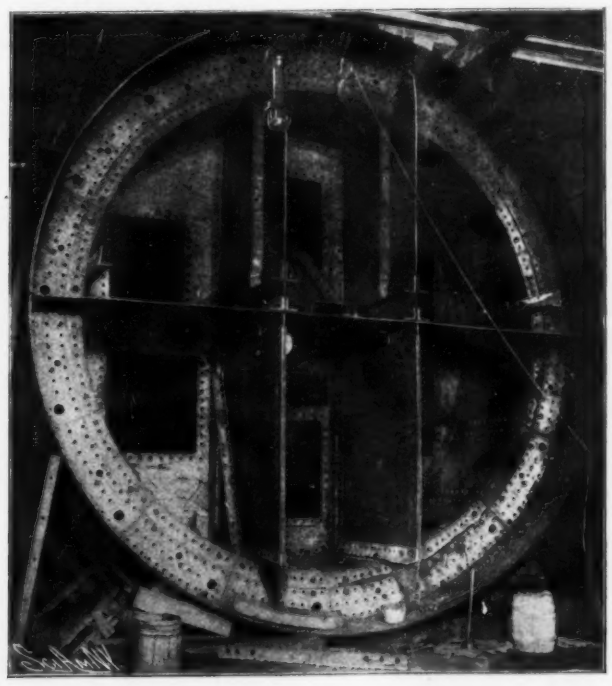


WORK AT THE HEADING OF TUNNEL AND VIEW OF PILOT.

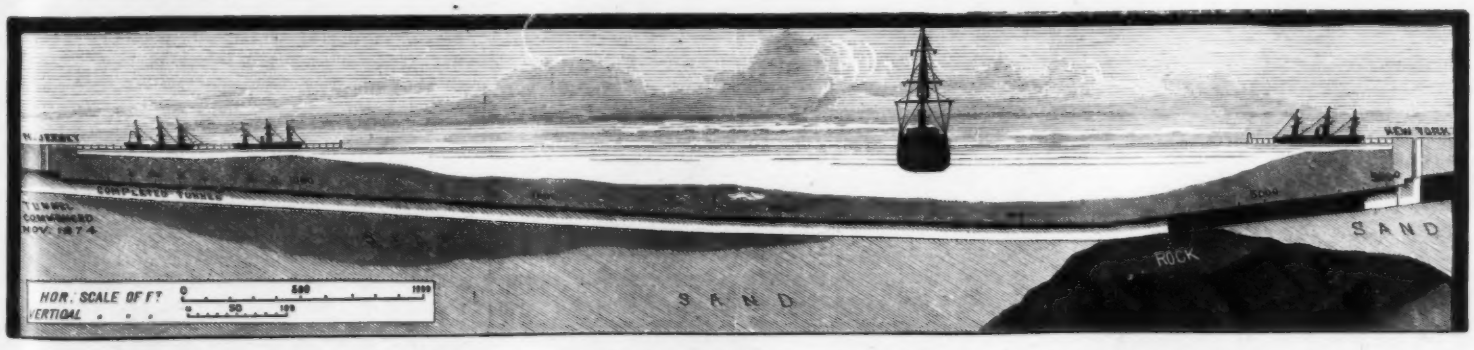


BLASTING OUT ROCK UNDER THE PROTECTING APRON OF THE SHIELD.

VIEW OF TWIN AIR-LOCK IN TUNNEL; SHIFTING RAILS FOR ENTERING LOCK CHAMBER.



FRONT VIEW OF NEW SHIELD FOR SOUTH TUNNEL.



PROFILE OF THE HUDSON RIVER TUNNEL NOW OPENED TO THE PUBLIC.

THE OPENING OF THE HUDSON RIVER TUNNELS.

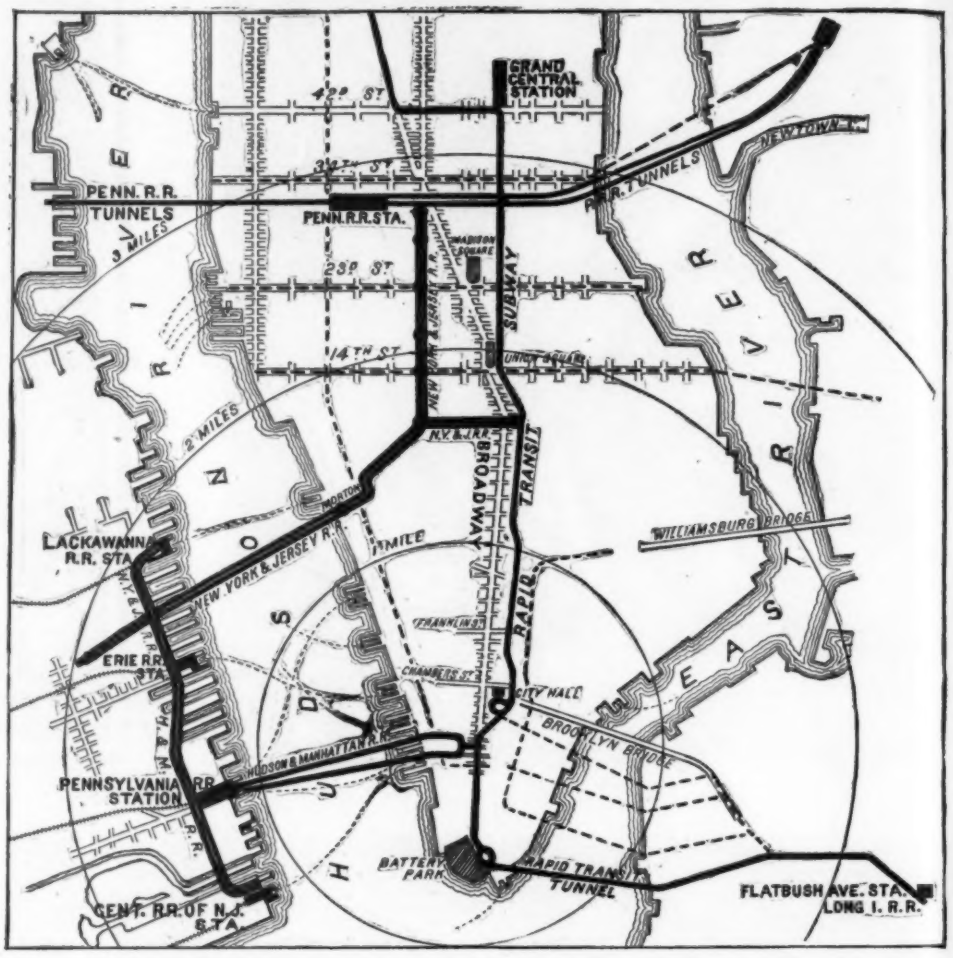
When Mr. McAdoo took hold of the enterprise, its scope was greatly extended. It was decided to build a second pair of tunnels to serve the "down-town" district, and also to connect the two sets of tunnels by a subway, which should extend parallel with the Jersey City shore line, and connect with the various terminals of the steam railroads in Jersey City. The system, as at present being built, consists of a two-track road, placed in two separate 15-foot tubes, which extends from the Delaware, Lackawanna & Western Railroad terminal in New Jersey, along the shore line to the terminal station of the Pennsylvania Railroad. At the intersection of the Subway with 15th Street, it is intersected by twin tunnels, which will extend from 13th, 14th, and Provost Streets, and connect with the two tunnels that have now been opened beneath the Hudson River to the Manhattan side. These two tunnel tracks have been carried beneath Morton and Greenwich to Christopher Street, and they will branch at the junction of 9th Street and Sixth Avenue into two separate pairs of tunnels, one of which extends beneath 9th Street to Fourth Avenue to a connection with the present Fourth Avenue Rapid Transit Subway. The other branch will extend ultimately north below Sixth Avenue to 33d Street, where there will be built a large station of ample size to accommodate the great traffic which is certain to seek this route. At present the Sixth Avenue tunnel has been completed to 19th Street and Sixth Avenue. At 33d Street, also, the system will be in touch with the Pennsylvania Railroad tunnel across Manhattan Island, and consequently, New Jersey traffic, both on the trunk steam railroads and on the surface trolley lines, will be placed in direct touch with the Pennsylvania tunnels and their extensive Long Island connections, and with the rapid transit system with its many ramifications in Manhattan and Brooklyn.

The Jersey shore line Subway, south of the intersection with the Morton Street tunnels, will tap the Erie Railroad terminal, the Pennsylvania Railroad terminal, and ultimately the terminal of the Central Railroad of New Jersey. The downtown tunnels, beneath the Hudson, consist, like the rest of the system, of two single tubes with a single track in each. They extend from the Pennsylvania Railroad terminal in New Jersey to a large terminal station, which is located on the two blocks on the west side of Church Street between Cortlandt and Fulton Streets. These two tracks diverge from the New Jersey shore, one of them passing below Fulton Street, Manhattan, and the other below Cortlandt Street. The down-town terminal, in addition to the underground tracks, platforms, etc., incidental to a station of this character, includes two twenty-story buildings, one between Cortlandt and Dey Streets, and the other between Dey and Fulton Streets, and the full cost will be approximately ten million dollars. From the station an underground foot passage will be constructed through Dey Street to the Interborough Subway at Broadway, where passengers will be able to make connection with trains for Manhattan and the Bronx and for Brooklyn.

It is seldom that an important engineering work of this magnitude is carried out as quietly as has been the work of excavating these tunnels and stations; indeed, there is one part of the work, the announcement of whose completion came as a great surprise to the New York public. We refer to the construction of a large subterranean station, 85 feet below the present terminal station of the Pennsylvania Railroad in Jersey City. So quietly has this work been done, that although the company has cut out of the solid rock a station 150 feet in width, and with its approaches nearly a thousand feet in length, not a word as to the progress of this excavation leaked out. The excavation is completed, and the task of concreting and finishing is completed. The station provides for four, and in some places five, parallel tracks and the necessary platforms. Passengers coming in from Newark, or from the Lackawanna and Erie terminal stations, can either continue to Cortlandt Street, Manhattan, or by taking the elevators which run from the tunnel station up to the concourse of the Pennsylvania Railroad station above, they can take a train to points on the Pennsylvania system, or take one of the surface trolley cars. Similarly, passengers arriving by way of the Hudson tunnel from Cortlandt Street can either take the elevators to the station above, to connect with local or long-distance steam trains, or they can continue through the Washington Street tunnel to the other Jersey City terminal stations, or they can continue their journey without change of car to Newark, the first three-quarters of a mile of the trip to that city being made in the tunnel, and the rest of it over the Pennsylvania Railroad steam tracks.

Special note should be made of the very rapid progress made with these two tunnels. They were forced through the mud by simple displacement; that is to say, the mud was crowded aside instead of being taken in through the vertical doors in the front of the shield, which was the method pursued in the earlier work on the Hudson River tunnels. The greatest record for one day was made on August 13, when one of the tunnels was advanced 72 feet in twenty-four hours.

The terminal at Cortlandt Street is by far the largest office building in the world. It contains twenty-two floors and four thousand offices. The site upon which it is being built extends for 400 feet on Church Street and 180 feet on Fulton and Cortlandt Streets. In order to find suitable foundations, it was necessary to go everywhere down to rock; and since the lower floors below ground level are also below water level, it was decided to inclose the whole of the area with a huge monolithic foundation wall of concrete 78 feet in height and 8 feet in maximum thickness. The sinking of this foundation was a task of great magnitude, and it was accomplished by means of rectangular caissons 8 feet in width by about 15 feet in length, which were sunk end to end, and entirely around the outside line of the building, down to bedrock. In order to key or dowel the adjoining blocks together, half-round forms were placed against the end walls of the caissons during the ramming of the concrete. These were subsequently withdrawn, the abutting sections of the caisson wall cut out, and the vertical circular hole thus formed was filled up with concrete tightly rammed in place. This not only keys the abutting sections of the walls together, but serves also to seal them against the inflow of water. That portion of the building contained within this wall, and lying below street level, has three floors, the first below the street being the concourse floor, the second the station floor for the tunnel trains, and the lowest containing the power plant. Above the street level the building is carried up as two separate structures, one on each side of Dey Street, built in the style of the Italian Renaissance. Up to the fourth story the building is finished in polished granite and Indiana limestone; above that it is of brick and terra cotta. An idea of the size of the building may be obtained by comparing it with the Broad Exchange building, which contains seven million cubic feet of space. It would take nearly three Broad Exchange buildings to fill the space occupied by the Cortlandt Street Terminal building, and in the four



By this system a passenger, landing at any of the Jersey City railroad terminals, will be able to take a train direct to central points between Forty-second Street and the Battery.

MAP SHOWING THE NEW JERSEY TUNNELS AND SUBWAY AND THEIR RELATION TO THE RAPID TRANSIT SUBWAY.

VIEW IN REAR OF SHIELD AT HEADING, SHOWING FULL DIAMETER OF TUNNEL (19 FEET 4 INCHES).

THE OPENING OF THE HUDSON RIVER TUNNELS.

thousand offices will be accommodation for at least twenty-five thousand persons. This great population will be handled by thirty-nine elevators, which between them will probably handle some thirty to forty thousand people daily.

THE TERMINAL STATION.—The trains arriving from New Jersey will enter the station on five parallel tracks, which will extend entirely across the length of the building, and will be served by six platforms. There will be absolutely no switching. The trains, which will consist during the rush hours of eight cars each, the cars being provided with both center and end doors for rapid loading and unloading, will discharge their passengers upon the platform on one side, and receive their passengers from the platform on the opposite side—an arrangement which entirely separates incoming and outgoing passengers, both on the platforms and on the cars, and conduces to great rapidity of handling.

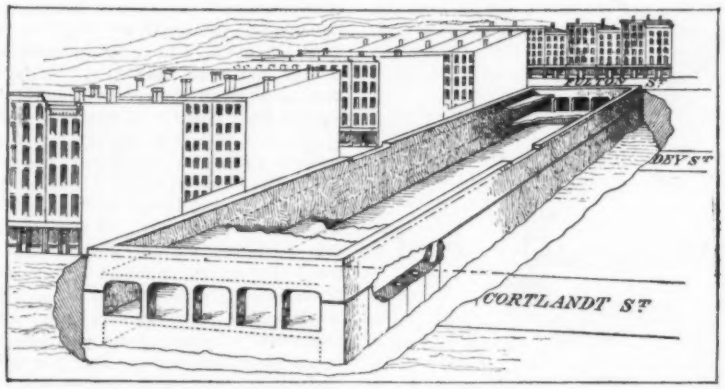
Passengers will enter the building upon the street floor and pass to the concourse on the floor below by stairways, inclined planes, and elevators. Here will be the waiting rooms, telegraph and telephone rooms, restaurants, and other conveniences of a large railway station. Access will be had from the concourse to the station floor by stairways and elevators. The cars, which will be built of steel, will be large enough to accommodate fifty persons. During the rush hours, it is proposed to operate eight-car trains on a headway of one and one-half minutes between trains; and as the passage under the river will probably average only three or four minutes, a resident of Jersey City should be able to reach the shopping district or downtown district in from six to ten minutes after leaving the Jersey side.

In conclusion, we may mention that as soon as the new Pennsylvania Railroad station at 33d Street has been completed, the big terminal station in Jersey City will be abandoned for steam trains and turned over for the use of the Hudson Companies, who anticipate such an increase in traffic that they will need all the tracks in both the tunnel and surface stations to accommodate the trains.

The cars are built entirely of steel. They are absolutely fireproof, and are constructed upon a plan differing materially from any others now used in the Metropolitan district. They have large, sliding side doors in the middle, as well as at either end, and the platforms are so arranged at the terminal stations that passengers enter and leave the cars at the same time. Those leaving go out on one side, and those entering the cars come in on the opposite side. This will do away with the congestion and crowding experienced at terminal stations on other Metropolitan railroads. All station platforms throughout the system are built on a tangent, or straight line, so that there is no dangerous space between the cars and the platform, such as is seen where stations are built on a curve. The doors of the cars are operated by compressed air, and no signal bells are used. When the last door in the train is securely closed, the motorman receives an electric flash signal, and starts the train. The automatic adjustment is such that the signal to start cannot be given so long as any door in the train remains open the fraction of an inch. The cars are brilliantly lighted and very comfortable. They have only side seats, and are equipped with steel rods set vertically at frequent intervals, to aid passengers in steadying themselves when trains are crowded.

Throughout the system, which, when completed, will comprise eighteen miles of under-river and underground railroad, the stations are designed with a view to comfort, permanency, and beauty. They are made large enough, not merely to accommodate the Metropolitan traffic of to-day, but to receive comfortably the greatly increased multitudes sure to travel by subsurface routes in the decades to come. Every part of the stations is constructed either of concrete or metal, so that, like the cars and the tunnel, they are thoroughly fireproof.

To the passengers who descend into the tunnel for the first time, the architecture of the stations is the most striking feature, and particularly so if they have an eye to the general fitness of things. The roof is formed of vaulted arches, which show a pleasant effect of light and shadow produced by the glow of incandescent globes.



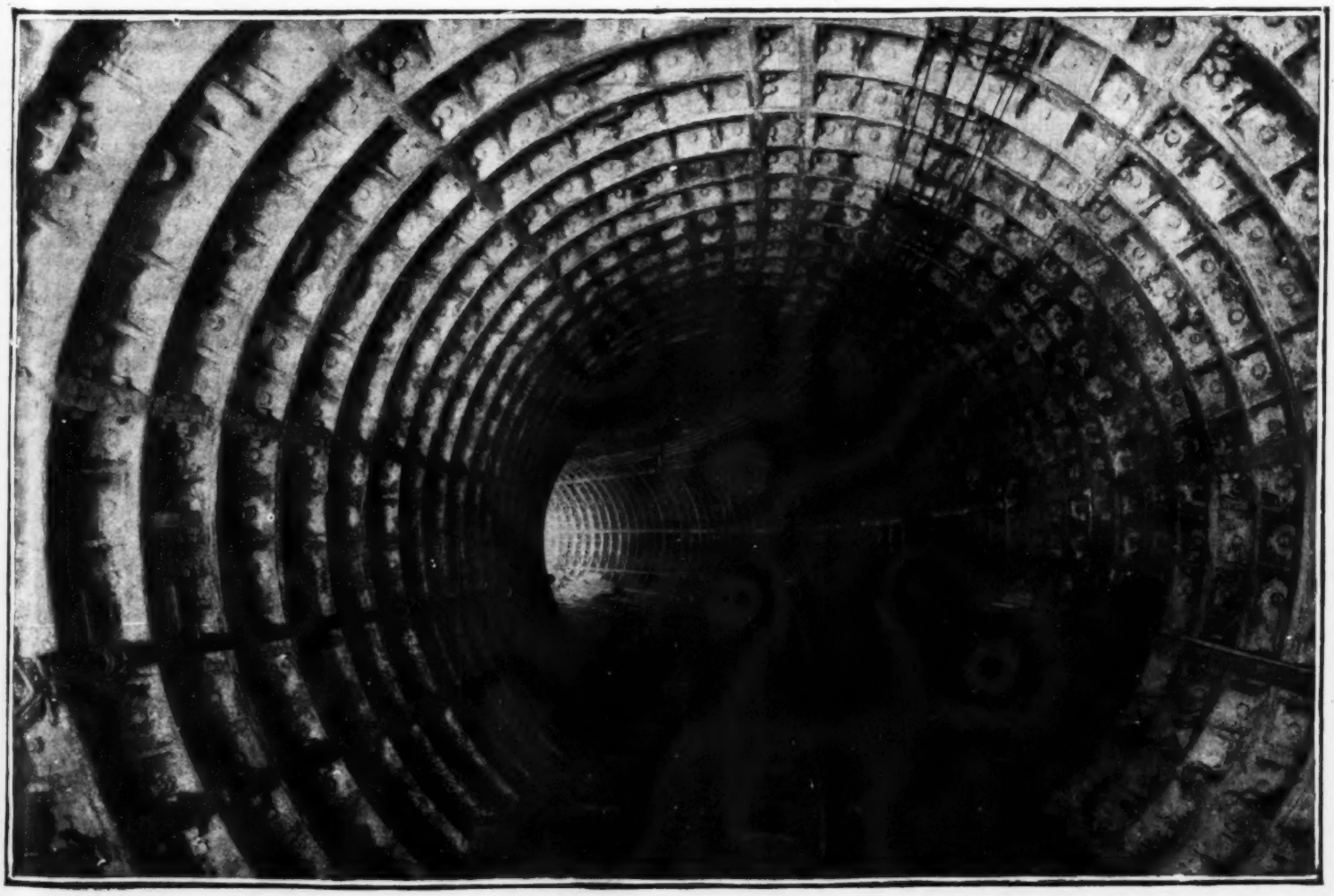
VIEW OF THE HUGE CONCRETE FOUNDATION OF THE CORTLANDT STREET TERMINAL STATION OF THE HUDSON COMPANIES TUNNELS.

It forms practically an unbroken rectangular box 8 feet thick, 75 feet deep, 180 feet wide and 420 feet long. The end walls are pierced to admit the five tunnel tracks.

HEAVY GOLD DEPOSITS AND A GOOD SOLUTION FOR PRODUCING THEM.

IN these days of "flash" deposits and "colors," the fact that heavy gold deposits are frequently desired is overlooked and many platers are not conversant with the method of making them. While the demand for goods of this kind is not extensive, as the cost is too high, occasions frequently arise in which such work is desired and, indeed, is often imperative.

One of the instances of this nature is that of the fine balances used in chemical laboratories. These are made of brass and lacquered. The lacquer is soon removed by the corrosive action of the acid fumes and the brass then becomes black and pitted. Some makers give the brass a "flash" deposit of gold, but as it is nothing more than that which is used for coloring cheap jewelry, its wearing qualities are no better, and perhaps worse, than that of the lacquer. Gold is quite non-corrosive, and a heavy gold deposit on such fine



Sharpest tunnel curve driven to date by hydraulic shields under compressed air.

TUNNEL CURVE OF 150-FOOT RADIUS AT MORTON AND GREENWICH STREETS.

THE OPENING OF THE HUDSON RIVER TUNNELS.

balances would preserve them from the attacks of acid fumes for a long time. While this is, perhaps, an isolated example, there are undoubtedly many others of a like nature upon which a heavy gold deposit would be gladly welcomed and paid for by a customer.

Although gold is one of the easiest metals to deposit from its solution, far greater care and skill are needed in making up such a bath than with other metals. The color of the gold deposit varies with the composition of the bath and its temperature, and the strength of the current so alters it that the highest skill and judgment are frequently called for in the production of gold deposits of a desired shade. If the plater obeys certain rules, however, the electroplating with gold, either in the form of heavy or light deposits should not bother him at all. The so-called "phosphate gold bath" used so extensively in the production of ormolu-gold work gives a yellow gold deposit. While this is much admired on certain classes of goods, on others it is hardly suitable. The phosphate of soda that is used in it increases the conductivity to such an extent that little gold is needed in it and, therefore, it is hardly suitable for heavy deposits unless the quantity of gold is increased. The color of the gold which it produces is too yellow for the majority of work. The "karat-golds" are admired, but such baths are not as easily worked as those which contain only pure gold and the deposit is not as rich. For richness and ease of working the use of pure gold is to be strongly recommended.

An excellent gold solution and one which is capable of giving a rich color is made by the use of chloride of gold and cyanide. Its simplicity is such that no one should have any difficulty in preparing it. It is made as follows:

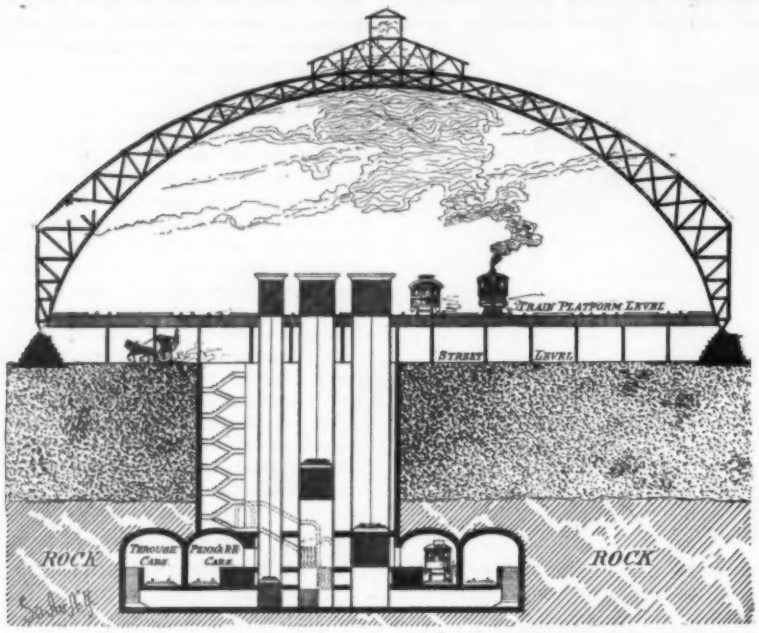
Water	1 gallon.
Potassium cyanide	3 ounces.
Sodium bisulphite	1 ounce.
Gold	½ ounce.

The gold is first converted into chloride by dissolving it in aqua regia (a mixture of 3 parts of muriatic acid and 1 part of nitric acid) and then evaporated in a porcelain dish until syrupy. The cyanide is dissolved in the water and then the gold is added and the whole stirred. The bisulphite of soda is next introduced and the whole is ready for use. The bisulphite of soda may be omitted from the formula if desired, but the deposit is brighter and more uniform when it is present. The quantity of gold that is given in the preceding formula is greater than that usually employed for gold baths, but if it is to be used for heavy deposits, it will be found none too much. If desired, the solution may be diluted with three or four times its volume of water and still obtain a good deposit. Under such conditions, however, the deposit is slower than in the concentrated solution. One advantage of this gold solution is the fact that it may be used either hot or cold. While the best deposits are always obtained in hot gold solutions, there are instances in which it cannot be done and the plater will be surprised to find how good a deposit may be obtained in the cold solution. It is not advisable, however, unless necessary, as the gold deposit adheres better when deposited from a hot solution for the reason that the cyanide is capable of dissolving any film of grease or oxide that may be on the surface of the brass that is to be plated.

If the articles to be plated are of steel or iron, they should be well freed from grease. Any oxide, of course, it is assumed has been removed in polishing. The electric cleaner will be found extremely serviceable for cleaning it, as it removes any wax, grease, or other foreign matter and leaves the steel in a perfectly clean condition. Steel may be gilded without first coppering, but it is usually advisable first to coat it in a hot cyanide copper solution. There may be instances, though, in which this cannot be done, and if this is the case, the steel may be gilded directly.

Copper or brass should be dipped whenever possible, as such a surface is clean and excellent for plating. If a polished surface is desired (it is really unnecessary for the majority of purposes), great care should be used in cleaning the surface preparatory to plating. Rouge should be removed by hot potash or lye and then, after rinsing, a dip in a weak cyanide solution will remove any discoloration. The next operation is the "quickening," or "blue dip." This is the regular solution used so extensively in silver plating and coats the surface over with a thin film of mercury. It is thus protected from oxidation and the mercury serves to bind the gold and base metal. For light gold or "flash" deposit, this dip must, of course, be omitted, as it destroys the color until a reasonable thickness has been deposited. For heavy deposits, it should never be omitted. The gold not only covers better, but adheres closer and seldom strips under the action of the scratch brush or burnisher. This "quickening dip" may be made in several ways and each seems to give equally good results. A simple method is to dissolve ¼ ounce of nitrate of mercury in 10 gallons of water and add enough sulphuric acid to produce a clear solution. The brass or copper is dipped for a second into this solution and it will become covered with a faint white film of mercury. If the solution is so strong that it produces a heavy, lustrous coat of mercury upon simple immersion, it should be reduced with water. A faint, bluish film is the best. The article should now be immediately immersed in the gold solution or, if it is necessary to keep it for any time, it is allowed to remain in clean water. The gold solution, as previously mentioned, works better hot, although it may, if desired, be worked cold. A good temperature is about 120 degrees Fahrenheit. The anode may either be of pure gold or platinum and the latter serves excellently, for the reason that the quantity of gold in the solution is so large that it is not soon exhausted. The operator will use his own judgment in the matter, but it should be borne in mind that, although a gold solution is fed from a gold anode, it sooner or later becomes contaminated and a new one is needed. This bath, however, should last several years when a gold anode is used and it is of sufficient size to feed it. Additions of chloride of gold and cyanide may be made from time to time as required. Many gilders prefer to exhaust their baths and then make up a new one. While this is excellent practice for "flash" gilding, it can scarcely be recommended for heavy gold deposits. When the gold becomes less and less in the bath, the deposit becomes slower and slower and it is difficult to obtain a deposit of a predetermined thickness.

The current that is used should have a tension of from two to three volts. Above this amount the deposit is "burned." This is indicated by the dark brown color and the fact that the deposit may be rubbed off with the finger. The first flash of gold is bright, but it soon becomes dull, and after a few minutes the surface has a dead brownish yellow color. If the deposition is allowed to go on, the gold will become granular. On this account it is taken out and scratch-brushed. This is absolutely necessary for the production of heavy gold deposits, and is really the "secret" of success (if this term may be employed in this instance). As soon as the deposit begins to become brown and without luster (usually from four to five minutes are required for the arrival of such a condition) the object must be taken out, rinsed, and scratch-brushed with a brass wheel or hand brush made of very fine wire. Good soap is used for lubricating the brush. The gold immediately becomes bright under the action of the brush, and after the whole surface has been brushed, the object is ready for returning to the gold bath. Before doing this, however, the soap should be rinsed from the surface and the object passed through hot potash or lye to remove any traces



SECTIONAL VIEW, SHOWING THE PENNSYLVANIA SURFACE STATION AND THE DEEP-LEVEL TUNNEL STATION BENEATH.

TUNNEL BENEATH MAINLAND, WITH SEMICIRCULAR ROOF AND VERTICAL WALLS.

FRONT END OF FIRST TRAIN THROUGH TUNNEL. CABLE SPLICING CHAMBERS SHOWN AT SIDE.

THE OPENING OF THE HUDSON RIVER TUNNELS.

of grease that might have been left from the hands. This alternate depositing of the gold and scratch-brushing may be carried on for a long time, and in this manner a very heavy gold deposit obtained. How long to carry on the deposition rests with the operator. In order to ascertain the amount of gold that is deposited on the object, it should be weighed previous to the deposition of the gold, and after the operation has been completed. If more gold is required, then it is returned to the gold bath and an additional quantity put on. In this manner a predetermined amount of gold may be used.

After the final gold deposit has been put on, the surface is ready for finishing. It should be well scratch-brushed as the preliminary operation to the final finish, and, if desired, it may be left in this condition. Gold is so soft that the scratch-brush produces a surface that is quite pleasing and for many classes of work it is quite suitable. The gold may be burnished, and when this is done, the deposit is rendered much harder and durable. Buffing may also be used, but is always accompanied by the danger of removing considerable gold, particularly on the edges of the object. It should never be attempted unless absolutely necessary, and if a polished surface is required, burnishing should be used. The color that is obtained is very rich and has a slight orange shade that is quite pleasing. The gold deposit that it produces is one of the richest of all the shades.

The steps in producing heavy gold deposits may be summed up as follows: 1. Carefully freeing the surface of the object to be gilded from grease. 2. Covering the surface with a slight film of mercury in the "quickening dip." 3. Depositing the gold with a current sufficiently weak to avoid "burning" it. 4. Removing the object as soon as the gold deposit becomes brown and dead, and scratch-brushing the surface. 5. Removing any film of grease from the surface by passing the object through hot potash or lye. 6. Returning the object to the gold bath and giving it another gold deposit. This is repeated as often as required. 7. Scratch-brushing the surface and then either leaving in this condition or burnishing.

A blood-stone burnisher is better for gold burnishing than steel and is extensively used.—The Brass World.

WILHELM OSTWALD.

A SKETCH OF A GREAT CHEMIST'S CAREER.

EMERSON, in his "Representative Men," defines a man of prominence as one who continually and without effort moves in a region of thought which other men are able to reach only by means of unremitting labor. In this catagory of model men stands Wilhelm Ostwald, in virtue of his individuality and the extent and comprehensiveness of his creative activity.

Wilhelm Ostwald was born September 2 (August 21, O. S.), 1853, in Riga, Russia. After completing the course of the German gymnasium in the old Hanse town he studied chemistry and physics (1872-1875) at the Russian university of Dorpat, where his career as a teacher also began. He was appointed assistant in physics in 1875, "privat dozent" or tutor in chemistry in 1878, and assistant in chemistry in 1880. In 1881 he was called to the polytechnic school of Riga as professor of chemistry. Here, in his natal city, the creative and administrative talents of the young scientist rapidly developed. In 1885-1887 appeared his "Textbook of General Chemistry" (Lehrbuch der allgemeinen Chemie), which, in conjunction with J. H. van't Hoff's osmotic theory of solution, opened a new chemical field—modern physical chemistry. In 1887, while still living at Riga, he founded the Journal of Physical Chemistry (Zeitschrift für physikalische Chemie), in the management of which he was associated with Van't Hoff. This journal, of which sixty volumes have now been published, forms a necessary part of the equipment of every modern chemist.

In 1887 Ostwald was called to the University of Leipzig, where he remained until 1906. In Leipzig he organized the Ostwald Institute, the first school ever founded for the special study of physical chemistry, which has attained world-wide celebrity, instigated its pupils to original work of great value, and become the model for numerous American college laboratories. The prominent position now occupied by the study of physical chemistry is due chiefly to the researches of Ostwald and his pupils, and to his books, lectures, and critical essays—in short, to the magical influence of his enthusiasm and his personality. As a writer Ostwald has been astonishingly prolific. He has published eighteen volumes which in bulk equal a good-sized encyclopedia. His "textbook" of physical chemistry (or "general" chemistry, to use his own expression) comprises several volumes and is written for the investigator. For the student he wrote "Elements of General Chemistry" (Grundriss der allgemeinen Chemie, 1889) and a "Manual of Physico-chemical Measurements" (Hand- und Hilfsbuch zur Ausführung physiko-chemischer Messungen, 1893). He reformed chemical analysis by his "Scientific Basis of Analytical Chemistry" (Die wissenschaftlichen Grundlagen der analytischer Chemie, 1894). His "Elements of Inorganic Chemistry" (Grundlinien der anorganischen Chemie, 1900) is useful to teacher and pupil alike and, finally, the principles and results of modern chemistry are explained in popular style in his "School of Chemistry" (Schule der Chemie, Erste Einführung in die Chemie für jedermann 1903-4). These works have become international through translations and have been kept up to date by new editions.

Ostwald has also taken great interest in the history of chemistry, which he regards as a most valuable means of quickening the interest of the student. His historical writings include his great work "Electrochemistry, Its History and Principles" (Elektrochemie. Ihre Geschichte und Lehre, 1896); "Classics of the Exact Sciences" (Klassiker der Exakten Wissenschaften, 1883), and subsequently, biographics of a number of pioneers in chemistry, and the recently published seven lectures on the history of chemistry (Leitlinien der Chemie, 1906). In his numerous public lectures and addresses, a collection of which is published under the title "Abhandlungen und Vorträge allgemeinen Inhalts" (1904), Ostwald exhibits a remarkable breadth of view, clearness of expression and beauty of style. His most distinguishing characteristic is his versatility and he presents a harmonious combination of the thorough specialist and the philosopher in search of general principles that shall bind together all

Prof. Dr. Wilhelm Ostwald

special fields of mental activity. He is one of the most conspicuous protagonists of modern natural philosophy and a cosmology based on energetics. In his "Lectures on Natural Philosophy" (Vorlesungen über Naturphilosophie, 1902) he unfolds a plan of the universe founded entirely on energy. To promote the culture of the "common ground of philosophy and special sciences" he founded, in 1901, the Annalen der Naturphilosophie. His endeavor is to establish a "science free from hypotheses," which he characterized as follows: "Its object is to see into the future and its completeness is in proportion to the extent and the certainty of this prevision."

But Ostwald is more than an investigator and a philosopher. He is also an artist who has done creditable work with brush and pencil, besides publishing various books: "Letters from a Painter: Contributions to the Theory and Practice of Painting (Malerbriefe, Beiträge zur Theorie und Praxis der Malerei, 1904); "Iconoscopic Studies," and "Art and Science" (Kunst und Wissenschaft, 1905). Ostwald is, furthermore, an enthusiastic advocate of the international language Esperanto and he asserts that science will never be satisfied until the linguistic barriers to its dissemination are swept away and a stop is put to the vast waste of energy that they have occasioned.

The extent and diversity of Ostwald's creative work have made him a man of international importance. He has received the honorary degrees of doctor of medicine, laws, and philosophy from many universities in Germany, England, and America, and he is an active or honorary member of the leading academies and learned societies of the old and new worlds. He is a privy councilor (Geheimer Hofrat) of the kingdom of Saxony and was the first man sent to America (1905-6) under the arrangement for an interchange of professors between German and American universities.

Ostwald is one of those rare men who are guided by their own principles and not by popular opinion. In 1906, while in the meridian of life and at the zenith of success, he voluntarily resigned his professorship at Leipzig and retired to his secluded estate "Energy," near Grossbothen. This unusual step was the logical consequence of Ostwald's theory of happiness. In the privacy of home and the bosom of his family he has sought the freedom in carrying out his own ideas that he could not hope to find in a great university.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Reclams Universum.

FLASH-LIGHT POWDER FOR PHOTOGRAPHERS.

FLASH-LIGHT formulas have been printed from time to time, but many of them have been of too dangerous a nature to recommend; and a number of accidents have followed their compounding. The discovery of amorphous phosphorus as an ingredient was the first real step toward safety. Mr. John Bartlett who first suggested it twenty years ago has recently published the formula under which the best commercial lights have been compounded.

The formula is: Mixed nitrates of barium and strontium, 5 ounces (2 parts strontium and 3 of barium); powdered and sifted metallic magnesium, 2 ounces; amorphous phosphorus (pure and dry), 120 to 180 grains. There must be no trace of free phosphorus mixed with the amorphous.

The barium and strontium are first heated in capsule to drive off all trace of moisture, finely powdered, and then mixed by sifting with the magnesium; when well mixed the amorphous phosphorus is carefully added by gently sifting. The substitution of 20 to 25 per cent of metallic aluminium in place of an equal amount of magnesium prevents any caking of the powder, which may occur when magnesium only is used, but as it has less actinic power than the pure magnesium, 25 per cent should not be exceeded.

Amorphous phosphorus is made by exposing phosphorus to a high degree of heat away from the reach of oxygen; it is a dull-red, inert powder when pure.

A very rapid combustion adds to the usefulness of a flash powder. This mixture lighted with a taper gives a flash of from 1/80 to 1/20 of a second. Pure magnesium burnt in special flash lamps last from ¼ to 1/10 of a second.

Electro-Chemical Coloring of Metals (according to Watt).—First comes the coppering. This is effected in a blue vitriol bath with the aid of a Daniell cell, after decomposition for 5 minutes or longer. Rinse the objects in hot water and immerse them in a 1 per cent solution of barium sulphide. The copper turns black. It is placed in hot, then in boiling water, next allowed to dry. The coating is polished with leather. With a few seconds' immersion, a rich brown tone is obtained; if different shades are required, cover the parts that are to remain yellow with paraffin, copper lightly and dry. On the parts to be dark, apply with a brush a paste of jeweler's rouge, which has been mixed, as may be desired, with barium sulphide. Then, under a stream of water, by means of a very soft brush, the paste is carefully washed off. When in spite of the paste the copper appears spotted, dip quickly in cyanide of potassium and then in boiling water.

PLANT PHYSIOTHERAPEUTICS.

THE MEDICINAL ACTIVITIES IN VEGETABLE MATTERS.

BY DR. W. E. EVERETTE.

IT has been gradually growing upon the mind of the active, truth-seeking physician, that the giving of drugs in the shape of all kinds of compounds and mixtures, hoping that some definite therapeutic action would be produced thereby, is all a mistake; and that it is now time for us to realize that we can economically obtain the concentrated, active, and potential principles from all of the medicinal vegetable matters, and quickly receive only the exact result that we require when giving such medicaments, without being obliged to use so much unnecessary drug material as has been heretofore used in the giving of medicines for disease.

In this article, I call close attention to the alkaloids, as they are the most potentially energetic of all of the active available principles of medicinal vegetable matters.

THE MEDICINALLY ACTIVE PRINCIPLES THAT ARE OBTAINED FROM VEGETABLE MATTERS.

1. *Ethionoids*... (Ether-Ion-Oids)	The excessively volatile nitrogenous oxidized hydrocarbons that are the "radio-active" organic *emanations*—both automatic and responsive—(most terrifically poisonous) that with *extreme analytical and chemical care*, may be extracted from certain forms of vegetable matters. (The *organic-etheric-ionic bodies*, that are constantly being "radiated" from certain forms of vegetable matters.)	
2. *Alkaloids*.....	The available medicinal and "concentrated" *potential energy* of the entire plant.	
	Amides—(C H N O)—*Fixed Solids*.	As strychnine, morphine, aconitine, etc.
	Amines—(C H N)—*Volatile Liquids*.....	As nicotine, cicutine, sparteine, etc.
3. *Glucosoids*.....	Usually an easily "fermentable" oxidized vegetable hydrocarbon..... (Very rarely contains any *nitrogen*.)	As strophanthin, salicin, etc.
4. *Neutraloids*.	The "non-fermentable" oxidized hydrocarbons of the plant..... (Somewhat related to *glucosoids*.)	As glycyrrhizin. As elaterin. As aloin. As santonin, etc.
5. *Amaroids*.....	The "bitter extractive principles" of the entire plant..... (As represented by the "bitter taste" of galenic medicaments.)	Of varying and indefinite chemical composition.
6. *Ether Oleoids*..... (Ester-Oleoids) (Etholeoids)	The natural volatile "ester ethers" of the vegetable matter..... The native odoriferous and ethereal "essential oils."	Can also be produced both synthetically and as artificial "essential oils."
	1. (Nitrogenated—$C_{20}H_{27}O_{11}N$).....	As oil of bitter almond.
	2. (Sulphurated)—C_3H_6NS).....	As ethereal oil of mustard.
	3. (Oxygenated)—($C_5H_{14}O_4$).....	As oil of eucalyptus.
	4. (Terpenes)—($C_{10}H_{16}$).....	As oil of turpentine.
	Synthetic forms of *Ether-Oleoids* may be produced from *Terpenes* by metamorphic action with heated water and added elements. And also many artificial "ester-ethers" (or Ether-Oleoids) may be produced by recomposition by similar thermo-aqueous action.	
7. *Fixed Oleoids*.....	The *non-volatile* "ester ethers" of the *fatty acids* that are taken from vegetable matters. These fatty acids are *Stearic*, *Oleic*, and *Palmitic Acids*..... (The "Fixed Oils," from seeds, beans, nuts, and fruits.)	As palm oil. As olive oil. As castor bean oil. As cocoanut oil. As croton oil.
8. *Resinous Oleoids*.....	The *native solutions* of the "resinoid" principle, naturally dissolved in the "ether-oleoid" of the vegetable matter..... A native "oleo-resin" of the plant.)	As oil of cubebs. As oil of capsicum. As oil of ginger. As oil of black pepper.
9. *Balsamoids*.....	The *Soft or Liquid* "resinoid" principle, containing the native "odoriferous" part of the plant, together with (usually both) cinnamic or benzoic acid	As balsam of tolu. As balsam of Peru. As balsam of benzoin. As balsam of styrax.
10. *Gumoids*.....	The *soft and usually non-hardening* "resinoids," as the *native exudations* of the vegetable matter. The naturally *dried sap* of the plant.....	As gum myrrh. As gum asafœtida. As gum acacia. As gum tragacanth.
11. *Resinoids*— (Native) 1	The *Solid or Semi-Solid* (induced or native) "uncrystallized" "resinous exudations" from vegetable matters of a more or less indefinite form of chemical composition.....	As resin of pine. As resin of jalap. As resin of podophyllin.
(Artificial) 2	Another form of "resinoids" are the concentrated—more or less—*entire* "fixed activities" (artificially produced) of the vegetable matter in a rather incompatible and antagonistic indefinite chemical mixture of *medicinal paste*.	As cactin. As juglandin. As hydrastin.
(Antagonistic qualities).. 3	*Jalap and* gives two antagonistic alkaloids—"pilocarpine" and "jaborine." The *poppy plant* is another illustration—as it gives "morphine" and "thebaine"—which are antagonistic to each other. From the *resinous opium* of the poppy plant there are obtained 18 "alkaloids," 2 "neutraloids," 2 "organic acids," and "sugar," "gums," etc.—more or less antagonistic to each other.	

ALKALOIDOLOGY.

1. Alkaloids, such as are used in the practice of the science of medicine, are composed of highly nitrogenous organic compounds, that are very closely related to the earth alkalies in their affinity to unite with acids to form crystallized salts.

2. Alkaloids belong to two physical classes, which chemically are called amides and amines.

3. An amide alkaloid is a complex compound of oxygen, hydrogen, carbon, and nitrogen, and is always in a solid state, and free from any appreciable odor.

4. An amine alkaloid is less complex in character, does not contain any oxygen, is very unstable to the action of heat, is a highly nitrogenous mixture of carbon and hydrogen, is always in a liquid state, and has always a more or less ammoniacal odor.

5. Alkaloids may or may not be native to the chemical constituents and substances of the vegetable matters that they are taken from as they may be produced by metamorphic action of the active principles of the plant during their process of extraction.

6. Alkaloids, normally in the original vegetable matters when in contact with putrefactive organic compounds and substances often change into another biochemical class of alkaloids that are named ptomaines. These secondary alkaloids—pto-amines—are seemingly the primal cause for most of the diseases that man is subject to, for they seem to set in action peculiar conditions for the spontaneous formation of various kinds of actual microbic growths. Here I cite algæ bacteria (SCIENTIFIC AMERICAN SUPPLEMENT, January 4, 1908). The experiments of Prof. Dunbar, director of the Hygienic Institute of Hamburg, show that bacteria, yeast fungi, and mold fungi are produced by algæ in organic and inorganic culture liquids. "The possibility of a higher species giving birth to numerous distinct lower species under the influence of particular chemical and physical agencies is an idea wholly new to biological science." "If Prof. Dunbar's conclusions are verified . . . a new light will be thrown on the origin of these lowly organisms." "After the theory of spontaneous generation of bacteria had been exploded by the researches of Pasteur, Cohn, and Tyndall, it was generally assumed that bacteria had existed since the beginning of life, as a constant species . . . Now, after years of preliminary researches, Prof. Dunbar has succeeded in observing the development of yeasts, and molds, as well as bacteria, from his pure culture of algæ."

7. Alkaloids are the most available concentrated forms of the total active medicinal constituents of all vegetable matters and therefore the alkaloids—both amide and amine—are the most important of all the organic compounds that are used in the practice of the science of medicine.

8. Amide alkaloids are such crystalline solids as aconitine, morphine, strychnine, etc.

9. Amine alkaloids are such volatile liquids as sparteine, cicutine, nicotine, etc.

10. Alkaloids are not only the most concentrated and energetic of the ordinarily available potential activities of the vegetable matters that they were extracted from, but, when properly extracted and isolated from their cognate antagonistic activities in the vegetable matter, can always be relied upon to be decisive in therapeutic action, are invariably of uniform amount of concentrative potential medicinal energy, and the alkaloidal salts made therefrom, being quickly soluble in always available liquids, are thus very valuable for rapid working when it is imperative to instantly administer the medicament hypodermically, or even intravenically, as shown by the researches of Baccelli, of Rome. They are trifling in quantity of dosage and are practically odorless—both conditions having special psychological values for the physician to realize. They are quickly soluble, easily absorbed, and practically palatable—if ever any medicament can be at all called palatable. They have less tendency to create anorexia or to cause nausea than any other form of medicament. For these aforesaid reasons alkaloids are the most important physiotherapic remedies, that we can obtain by our entire knowledge of the physical therapeutics, that we can employ from the use of our materia medica. For alkaloidal intravenous therapy, see "La Via delle Vene Aperta ai Remedi Eroici" (G. Baccelli, Rome, Tipografia Nazionale, 1907).

11. It is a law in physiotherapy that organic nitrogenous medicaments have the greatest activity as poisons, as nervines, and as remedial medicines over any other class of medicament, whether galenical or mineral.

12. An alkaloid in high maximum dose will always have an opposite and an entirely different kind and degree of therapeutic action than when the same alkaloid is administered in a low minimum dose.

13. An alkaloid—or in fact, any medicament—in high maximum dose will always depress the physical energy of the body, whether in health or disease.

14. Per contra, any class of medicaments, alkaloids included, when given in low minimum dose, will always stimulate the physical energies of the body, whether healthy or diseased.

15. Any class of medicament having a high organic nitrogenous content, when given in maximum dose, will always act powerfully as a depressant on the entire nervous system, whether in health or illness.

16. Any class of medicament having a high nitrogenous content, when given in a minimum dose, will always act powerfully as a decided stimulant on the nervous system, whether in strength or weakness.

17. Alkaloids, as they consist very largely of nitrogen, can be depended upon to give exactly the kind and degree of therapeutic action and result that is desired and required by the physician whenever the giving of medicaments is necessitated for nervous diseases.

18. Alkaloids, therefore, are the best therapeutic stimulants and depressants that we can use as remedies and medicinal agents.

19. Glucosoids, or glucosides, are compounds of oxygen, carbon, and hydrogen, and, very rarely, sometimes contain a slight amount of nitrogen. In contact with any organic fermentive process, or in contact with inorganic aqueous acids, they change into glucose, with formation of phenols, aldehydes, and alcohols. Salicin, strophanthin, etc., are varieties of glucosoids.

20. Neutraloids are non-fermentable oxidized hydrocarbons that are somewhat related to glucosoids. Aloin, elaterin, and glycyrrhizin are varieties of neutraloids.

21. Amaroids are the bitter principles of vegetable matters, of somewhat varying chemical composition, and are represented in the bitter taste of all galenical medicaments.

22. Ether oleoids are the volatile and odoriferous extracts either native to the vegetable matter or chemically produced by a recomposition with heated water. When containing nitrogen such forms as oil of bitter almond are produced; when containing sulphur ethereal oil of mustard is produced; when containing oxygen such forms as oil of eucalyptus are produced, and when consisting of carbon and hydrogen the terpenes are formed, such as oil of turpentine.

23. Fixed oleoids, as the fixed oils, are the non-volatile ester ethers of the fatty vegetable acids, such as organic fatty acids, as palmitic, stearic, and oleic acids. They are produced in the form of the oil of olive fruit, castor bean, cotton seed, nearly all kinds of nuts, Croton oil, and from all forms of fatty, oily vegetable matter.

24. Resinous oleoids, as oleoresins, are the native solutions of the resinoid principle normally dissolved in the native ether oleoid of the vegetable matter. They are produced as the oils of cubeb, capsicum, ginger, etc.

25. Balsamoids are the plastic or liquid resinoids, as exudations from vegetable matter, containing the native odoriferous principle of the plant, with usually both benzoic and cinnamic acids. They are produced as balsam of tolu, balsam of Peru, balsam of benzoin, etc.

26. Gumoids, or gum-resins, are the soft, semi-solid, non-hardening resinous exudations from vegetable matter, such as gum asafœtida, gum myrrh, and other gummy substances.

27. Resinoids are the hard or soft concentrated compounds of induced or native uncrystallized exudations from vegetable matters. Certain forms of resinoids take in the entire fixed properties of the plant, and are therefore never of definite chemical composition, nor can they ever contain all of the volatile active medicinal part of the vegetable matter they were formed from. The natural exuding resins of vegetable matter are produced as the resin of pine, resin of jalap, resin of podophyllin, etc., and the artificially concentrated resinoids of the entire plant are produced as cactin, hydrastin, juglandin, etc.

28. By a study of the above analysis of the available medicinal constituents of plants we therefore find that the most potentially energetic of all of the available active principles of our medicinal vegetable matters are the alkaloids. For, as heretofore explained in paragraph 10: (*a*) The alkaloids contain all of the medicinally potential energy of the plant, in a commercial sense; (*b*) the alkaloids are always uniform in their amount of concentrative energy; (*c*) the alkaloids are positive and decisive in their therapeutic

action, whether as a desired depressant or as a stimulant; (*d*) the alkaloids are quickly and easily soluble and are small in necessary quantity of dosage; (*e*) the alkaloids are free from causing any excessive nausea or anorexia; (*f*) the alkaloids are neatly administered, and are free from any repugnant medicinal odor.

29. The Poisonous Emanations from Vegetable Matters.—We have now taken out all of the normal medicinal extractive principles from vegetable matters. But there are other potential forces and activities in vegetable matters that are rarely known or heard of outside of certain chemical laboratories of highly skilled analysts. These other potential forces are the excessively poisonous nitrogenous oxidized hydrocarbons that are the etherial and extremely volatile organic radio-active emanations from certain plants—that practically are the supernormal activities of the vegetable world. These organic and excessively volatile and dangerously poisonous nitrogenous vegetable emanations have a somewhat similar radio-activity to morganic radium and thorium compounds, both in an automatic and in a responsive sense to each other, in different conditions of concentrated, i. e., vapory and condensed, emanations. These extremely poisonous, and very volatile radio-active organic nitrogenous oxidized hydrocarbon vegetable emanations are constantly being given off by certain plants, and (when not artificially concentrated or condensed into a vapory or a liquid form) seem to have a more or less beneficial oxidizing action on the carbon of the microbic life, i. e., bacteria, that is always, to a greater or lesser extent, in the surrounding atmosphere of the normal environment of the plant. Certain of these radio-active vegetable nitrogenous emanations when in concentrated condensed form are so terrifically poisonous that when inhaled they will cause death by instant paralysis of both the sensory and the motor nervous systems, and also are instant death to all forms of insect life when in the atmosphere of its excessively volatile vapor or emanation, when condensed into a vapory liquid, and allowed to volatilize or evaporate into the air. I have named these volatile potential forces from vegetable matters "ethionoids," from their etherial, ionic nature, as they are the organic-etheric-ionic bodies that are constantly being radiated from vegetable matters to a greater or lesser degree, depending on the environment, the soil, and climate, and the botanical character of the plant. Whether or not we will ever be able to condense these radio-active vegetable nitrogenous emanations into available liquids for concentrated medicinal purposes is about as difficult a medico-chemico-legal question (on account of their intense volatile poisonous qualities, together with their leaving no trace in the body after death for ordinary chemical analysis to find) for the student of synthetic and analytical chemistry and medicinal practice to solve as is the related question of accurately defining the supernormal of the mental faculties of man to the student of the so-called psychic phenomena of telepathy, clairvoyance, clairaudience, hypnotism, etc., that is now being very carefully and practically investigated by students of science. But, as no study can ever possibly be too great for man to learn, therefore, *crede quod habet, et habet.*

THE PLAGUES OF HISTORY.

THEIR PERIODIC QUIESCENCE AND RECRUDESCENCE.

THE epidemics of the East and West have generally been more or less synchronous with one another. The last pandemic of plague was in full activity in the seventeenth century and covered a large portion of Asia, Africa, and Europe, but toward the end of the century the disease began to contract its limits, leaving Western Europe free in the course of a few years, a freedom which, with one notable exception, has continued. That exception was the epidemic in 1720 in Marseilles, when 60,000 of its inhabitants died from plague which had been imported from the East. As regards the rest of Europe the retrocession continued, and in the course of 150 years plague not only disappeared from Europe altogether, but also showed a remarkable cessation in its old endemic centers of Mesopotamia and Arabia. What remained of the disease was shown by Tholozan to pass through a very definite stage of development, being mild at first, then virulent, and again mild, and the preponderating element was mildness. The mild plague consisted of glandular swellings unaccompanied by fever, the swellings showing themselves in the groin, armpit, or neck. The epidemics which Tholozan studied were observed by him to be self-limiting in their extension, and, as he points out, were not controlled by the plague measures which were often adopted after the plague outbreak had ceased. Within recent years the plague epidemics that arose from the old centers in Mesopotamia and Arabia were apparently incapable of wide extension and even under conditions seemingly most favorable for their spread. The conclusion from Tholozan's researches appeared to be that for epidemic plague endowed with qualities of diffusion, whatever that may mean, no quarantine on land would stop its progress, while for other epidemics of a self-limiting character quarantine on land was not required.

Following the retrocession and contraction of plague Europe has remained free for over sixty years, broken only by a short but virulent outbreak on the Volga in 1879, investigated by Dr. J. F. Payne and Surgeon-Major H. Colville; by a small outbreak at Oporto in 1899, and a few cases at Glasgow and Naples in 1900. Western Europe has been free for nearly 200 years, the last epidemic being at Marseilles nearly 187 years ago. The Great Plague of London occurred more than 240 years ago.

Quiescence of plague for varying periods is not a new feature in the history of the disease. It is necessary to emphasize this fact, for the long quiescence in Western Europe has given rise to the view that Europe has seen the last of its plague epidemics, and accordingly the epidemic now prevailing in India is viewed with regrettable complacency. I think this view of the invulnerability of Europe is as likely to be correct as the prevalent notion that London was freed of plague by the Great Fire, irrespective of the fact that plague remained in London for fourteen years after and that the disease disappeared from the whole of England and most of Western Europe about the same time.

Subsequently to the Justinian plague and its offshoots Europe, with the exception of an epidemic in Constantinople in 697 and another in Sicily, Calabria, and Constantinople in 749, remained free from plague for four hundred years, and Syria, which is nearer the endemic center of Mesopotamia, remained free for two hundred years. Bagdad itself in the center of the endemic area remained free for some fifty years at the commencement of the Abbasidic dynasty at a period of unexampled prosperity. Moreover, Egypt, which has suffered at varying intervals from devastating epidemics of plague during the past 2,000 years, remained free from the disease from the eighth to the eleventh century, or a period of 300 years. Long immunity of towns as of countries is also not uncommon in regard to plague epidemics even when plague is in the country. When Bombay was attacked with plague in 1896 it had been free from the disease for 184 years; when Moscow was attacked in 1771 it had been free for 150 years, and when London was attacked in 1499 it had been free for 150 years.

Various explanations have been given of the retrocession of plague from Europe. It has been ascribed to the social and sanitary improvement of the people since the seventeenth century; it has recently been set down to the invasion of the *Mus decumanus* at the beginning of the seventeenth century, and the retirement, except from the seaports, of the *Mus rattus;* and it has been attributed to the abandonment of overland routes as the principal means of transport and communication between the East and West, to the substitution of sea routes, and to the introduction of quarantine at seaports trading with infected countries. None of these explain in a satisfactory manner the sudden retrocession of plague which stands as a remarkable epidemiological fact, but individually and collectively they may have exercised an important influence in keeping the disease in check once it had receded. Probably the most powerful of these was the change of land routes to sea routes whereby the transport of goods from the East to Western Europe was no longer effected by caravans which passed through the endemic centers of plague in Mesopotamia and Arabia. It was a change which must have materially lessened the chances of infection and of importation of the disease. From this point of view the new railway schemes which are to link the East with the West and reopen the old overland trade routes are not unlikely, unless special precautions are taken, once more to bring with them the risks of plague importation.—Prof. W. J. R. Simpson in a paper on "Plague" read before the Royal College of Physicians, London.

HEUSLER MAGNETIC ALLOYS.

THE discovery made five years ago by Heusler that the addition of manganese to copper produced an alloy strongly magnetic raised a faint hope that useful results might come from this discovery. Up to the present time, however, no application of the magnetic property of these alloys has been made, and we are still entirely dependent upon iron in its various forms. The reason for this is that the new alloy is relatively poor magnetically when compared with iron, and, moreover, the metals entering into its composition are themselves more expensive than iron or steel. There seems to be little possibility of any developments in this direction, though the discovery suggested that it might be possible to produce an iron alloy of decidedly better quality than the steels used to-day. It will be remembered that this same suggestion followed from a discovery made several years before the magnetic quality of the Heusler alloys was noticed. This was that the addition of certain materials to iron tends to increase the resistivity and at the same time improve the permeability. It was suggested that it might not be impossible to cast armature and transformer cores without increasing the internal losses, and we might thus avoid the expensive and laborious methods to-day necessary in constructing these parts of our machines. However, all that has come of these discoveries is the production of a number of brands of special steel for electrical work, without any change in the method of construction.

Hence, the interest in the Heusler alloys has been mainly scientific, and it is probably for this reason that the investigation of their properties has not been carried on more energetically. From time to time, however, a contribution to this subject is made. The latest of these is a paper read before the Royal Society of Edinburgh last fall. In this, Mr. D. A. Ross described a number of experiments conducted in order to determine the effects of heat and cold upon the alloys. Heating the alloys slowly and allowing them to cool was found to increase the hysteresis loss, just as aging increases the loss in transformer cores, although a short, moderate heating caused a temporary decrease in the losses. Cooling increased the permeability; in fact, immersing the specimen in liquid air gave an increase of nearly 30 per cent, though this was only temporary. This increase, however, was followed with a slight increase in the hysteresis. When the specimen was allowed to stand it slowly returned to the original condition. It was found, however, that when a specimen was cooled, then heated and quenched in cold water, the permeability and the hysteresis effect were both decreased. If the specimen was then cooled in liquid air it regained its original permeability without suffering a change in the hysteresis effect which had been decreased by the previous quenching.

These experiments seemed to be in agreement with the recent ideas regarding magnetization. A recent theory, suggested since the discovery of the Heusler alloys, is that magnetization is an effect of molecular grouping, and not a special property of the atoms, hence any physical treatment which might tend to change the physical state of the body should have a marked effect upon its magnetic properties.—Electrical Review.

VIBRATION IN STEAMSHIPS.

VIBRATION in steamships is probably unavoidable, no matter what means of propulsion are employed. The turbine steamers "Lusitania" and "Mauretania" vibrate considerably in certain parts, much to the disappointment of those passengers who expected to be entirely relieved of this discomfort. The steam turbines, being perfectly balanced, contribute little or nothing to the vibrations, but the propelling screws and the action of the waves, which are also important sources of vibration, have to be reckoned with. The steel hull is a highly flexible and elastic structure which responds to every exterior and interior impulse. Even if it were made of one solid mass of steel, the elasticity and flexibility of a structure 790 feet long would still be very appreciable. The possible extensibility of a steel bar 790 feet long when subjected to a stress of 30,000 pounds per square inch is about 9½ inches, taking the modulus of elasticity as 30,000,000. The hull of an ocean steamer is, of course, much more extensible proportionally than a solid steel bar because of the shape and unavoidable looseness of structure. A small fraction of the possible relative motion of the parts of such a structure repeated many times a minute is quite enough to produce a very disagreeable effect.—Machinery.

If the points of wire nails are flattened to a chisel point, and this point set at right angles to the grain of the wood, the nails may, according to Zentralblatt, be driven into wood without danger of cracking it.

ELEMENTS OF ELECTRICAL ENGINEERING.—XII.

CONJOINT OPERATION OF DYNAMOS.

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Continued from Supplement No. 1676, page 102.

IN the ordinary operation of even a small central station, more than one electric generator of a given kind is necessary. Reliability of service is alone insured by having reserve apparatus for instances of unexpected and abnormal loads and for recourse in case of accident. Aside from these reasons, one dynamo could not well carry the widely variable load; for, if large enough to deliver the maximum demands, it would be working under uneconomical conditions during light loads. Though dynamos are being built in continually larger sizes, it has not been found advisable to install much larger "units" than correspond to the minimum load. In a small plant, it may, however, be best to have one small generator for the day or late night load, a large one for the principal load, while the two could work together for coping with extra demands. A second large machine would supply the needed reserve. In case of series arc lighting dynamos, a practical limit has been reached in the 125 and 150 light sizes. Beyond that, safety of insulation has not been attained.

The particular switchboard equipments for connecting and controlling dynamos will be explained in later articles, but in this will be given some of the possibilities in these joint operations, together with some of their limitations and precautions.

It is a magnificent and thrilling sight, though with more than half the truth invisible, to watch ponderous generators continually urged to their work, with the unrelenting power of the engine, each struggling with its own assigned task, unconscious of that of others, or sharing its burdens in a manner too uniform to be human. Yet this even tenor could be turned into confusion and actual disaster by the mere opening or closing of some apparently inconsequent switch. The trained switchboard operator knows just what he can do with the various circuits, and to his, not magical, but intelligent touch, the machines, with their latent forces of destruction, yield a silent service.

As mentioned in earlier articles, dynamo machines are highly specialized, and when designed for some particular work will do that well, but may be wholly unfitted for other uses. Thus a series arc dynamo would not be at all practical for lighting incandescent lamps, nor could it work in any connection with one adapted for that class of service. Dynamos of the same kind, however, can, and often do, work in electrical connection with each other.

The first dynamos were of the series type, and the lamps which they operated were all connected in series; still, the early machines were small, and for economy of wire two such machines could readily be connected in series, like two batteries, and operate a single circuit of twice as many lamps as could either alone. It was simply necessary to couple the positive pole of one dynamo to the negative pole of the other. A diagram of the connections is given in Fig. 44. The terminals of a series dynamo consist essentially of one brush and one field end, and these are marked + and —, respectively. The + of No. 2 is attached to the — of No. 1, while the + of No. 1 and the — of No. 2 form the extreme terminals to which the circuit of arc lamps is connected. In the early days of electric lighting it was common practice to run two 40 or 50-light dynamos in series, but the present larger sizes avoid this practice and economize space and power in the central station. For operation in series it is not, however, necessary that the units should be of the same size—the Brush Company frequently would put a 40 and a 16-light dynamo together and light 56 lamps. Difference in size meant only a difference in the number of volts, but with the same size of wire both could carry the same current.

Though now obsolete for arc lighting, this ability of series dynamos to operate in series has received remarkable development at the hands of Thury in France. He has made successful machines for 20,000 volts, and by putting several such in series, accomplished some practical long distance transmissions by the use of direct currents. Though alternating currents possess peculiar qualifications for long-distance work, and are ordinarily employed, they introduce some troublesome factors not found with direct currents. Thury is now reported to be working on a scheme of putting seven of his generators in series, and transmitting several thousand horse-power by direct currents from the River Rhone to Paris. The same proposition is being made for the transmission from the Victoria Falls to Johannesburg in South Africa.

Two ordinary series dynamos cannot be connected in parallel to supply a common circuit. The reader can easily see the reason if he draws a diagram in which the + poles are connected together and to a line wire, and the — poles also connected together and to the other line wire. Then draw another diagram showing two identical series machines connected so that one can be called the generator and one the motor. Now, ignoring the line wires in the first diagram, it will be

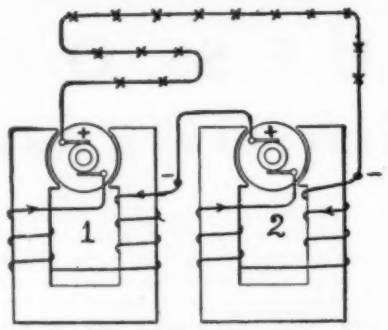

Fig. 44.—Series Wound Dynamos in Series.

seen that both are identical; that is, the connections that apparently are proper for parallel operation are coincident with those for motor operation. Just which would be the motor and which the generator it would be impossible to say, and in a critical case the two machines could actually be supplying current to the exterior circuit in parallel; but, by any change in speed, or otherwise, let one fall behind the other in voltage, by the least amount, and this ticklish or unstable condition would at once disappear, current would flow backward through one machine, its field magnetism would be reversed, and the armature would try to rotate as a motor in the *opposite* direction. If still positively driven in the same direction, both machines would be in series on a short circuit with evident ruin.

A possible method, but limited in usefulness in consequence of being applicable to only two machines at a time, is that of mutual or exchanged excitation. In this, the current from one armature, instead of passing through its own field, energizes that of the other machine. Fig. 45 shows the scheme. If the path from the + brush of No. 1 dynamo is followed, the current passes to line, and returns to field of No. 2, and then back to — brush of No. 1; similarly, current from + brush of No. 2 will pass to line, then around field of No. 1 and return to — brush of No. 2. By this device, if one armature tries to generate more current than the other, it will at once strengthen the field of the other, and thereby compel it to generate an equal amount. There is practically no engineering application for currents from series dynamos operat-

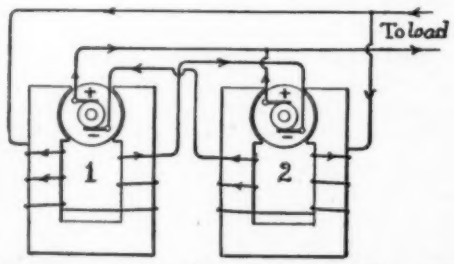

Fig. 45.—Series Dynamos in Parallel—Mutual Action.

ing in parallel, so this method of connecting is of little more interest than a laboratory experiment. With functions reversed, the scheme has occasionally been used to allow two shunt motors to operate conjointly in driving a common line of shafting. A few series turns are added, therefore giving the appearance of compound winding, but the main current in one armature passes around the series turns of the other field, in the direction opposite to that in the shunt. If now, one motor tries to assume an undue share of the load, its larger current will sufficiently weaken the field of the other motor to compel an equal sharing. To weaken, and not strengthen, this field is the proper procedure, for by weakening the field, the armature must go faster to generate its requisite counter electromotive force, and in trying to go faster it assumes its proper share of the load.

A second method of operating series dynamos in parallel, and without being limited to two machines, is by use of an additional common connection called the "equalizer." Its location is seen in Fig. 46, and here happens to connect with the negative brushes. The particular polarity is, however, unimportant, the essential feature being that it is the beginning of the field winding. Similar brushes are shown connected at *a*, while the outer terminals of fields are connected together at *b*; the addition of the equalizer has merely served to put the two field windings in parallel. If the two generators are alike and are sharing the load equally, the current will divide at *b*, half returning to each field and armature. If by some fluctuation in speed, or from any other cause, the voltage of No. 2 falls below that of No. 1, a proportionately greater strength of the current would flow from the line through the field of No. 2, and by the equalizer path to armature of No. 1, than by way of field of No. 1. This unequal division would at once increase the strength of field of No. 2, and diminish that of No. 1 until an equalization of voltage was restored. In actual running, however, these interchanges of current are first one way, then the other, through the equalizer, as shown by the double arrow, and the corrections are almost instantaneous. Were a third machine, or still others added, the equalizer would be extended to embrace them also.

When dynamos are connected in series, they must needs carry the same current, but as already instanced, their voltages may be widely different. In parallel, these factors are reversed; the voltages of the various machines must be kept constant, but each can supply a strength of current quite different from the others. Steam boilers of different sizes may work together, in their ordinary parallel connection, but though supplying all the same pressure, they do not need to be of the same size. It will be inferred that to secure harmonious or even tolerable working of dynamos in parallel, they must have similar proportioning as regards their magnetic and electric circuits. The fall of potential in each, due to the resistance of the windings, must be proportionate to the size, and the degree of magnetization of the iron must be similar in each. The iron should be far from saturation, else when greater current flows through the series coils, no opportunity to realize more magnetization will be afforded. Field magnets must then be liberal in size and of good material, or constancy of line potential will be impossible.

The preceding case is not of much importance in itself. Plain series wound dynamos are not worked in parallel. No sort of commercial service can be conceived that could be well served by such arrangements, and the reason for the explicitness of the explanation is to be found in the regular operation of "compound" wound generators. Shunt machines naturally precede this sort.

Fig. 47 shows the connections, with a little more completeness than those in the cases already considered; field rheostats, or regulators, ammeters, and voltmeters are included. One voltmeter may serve for an indefinite number of similar machines, and there is some virtue in this seeming economy, for since the different machines are to generate the same voltage, it is more important to measure them by the same instrument than to depend upon individual ones that might readily disagree to the extent of a few volts. The rest of the switchboard apparatus requires repetition for each machine. Symmetry of connections is an important feature; if the upper brush of one dynamo is positive, the corresponding brushes of all the others should also be positive; if the left-hand blade of one switch is positive, then the left-hand blades of all the switches should be the same. The main conductors with which the different machines connect, and which convey all the current, are denoted as the "omnibus" or for short, "bus," bars; of these, the positive is usually the upper. Double-pole switches are regularly inserted in the mains from each dynamo, but in this diagram the positive lead is shown permanently connected, while a single-pole switch is in the negative main.

In the operation of a central station for incandescent lamps and motors, no suspension of service is supposed to be allowed, but that at least one machine is running and keeping the system "live." The voltmeter, like the pressure gage on a boiler, gives indication of the voltage; if not normal, the field rheostat is changed to restore the proper pressure; the current output is shown by the ammeter. If the demand for

current is increasing, and the one machine is nearing its full load capacity, a second machine must be started. Its main switch is presumably open, and when full speed of armature is attained, the potential is made equal to that between the bus bars. The switch is now closed, but still no current flows from the second machine to help supply the line; neither does it receive a current from the line. As long as the potential remains equal to that between the bus bars, no current can flow either way; the two electromotive forces are just equal and opposite. If, now, some of the resistance in the field rheostat of the new machine be cut out, the potential will rise, and any desired share of the load may be assumed; simultaneously, some resistance may be cut into the other rheostat and relieve the load on the first machine.

Field rheostats waste but little energy, and allow an extreme and all-important control of constant potential dynamos. To take a machine out of service, reverse steps are followed; resistance is cut into its rheostats until the ammeter needle points on zero, then the main switch is opened. Although this latter must be of size sufficient to carry the entire current, it is not supposed to be closed or opened when any considerable current is flowing, for disastrous and unnecessary burning of contacts would result. If large currents are likely to be in need of rupture, special switches, called "circuit breakers," are needed. Some explanation of a common form will be given in connection with switchboard appliances in a later chapter.

Shunt wound dynamos in parallel form a very reliable and simple equipment for a station. This was the original Edison arrangement and is still to be preferred for uses except those where self-regulating qualities with rapidly changing load are imperative. Especially in connection with charging storage batteries, where the load for many hours is practically constant, is the plain shunt machine highly satisfactory.

For railway or other power service, manual control by a field rheostat would be impracticable. Variations of load are sudden and severe; mechanical control by devices once used by Weston and Maxim are out of place from their extreme sluggishness, or intolerable sparking. Automatic control by use of compound field winding is a beautiful and effective solution of the problem. Since the shunt portion of the winding furnishes the greater part of the energy of the field, all the requirements shown in Fig. 47 are still needed. In consequence of the series portion, the device of the equalizer shown in Fig. 46 must not be omitted. Fig. 48 represents the combination, the main circuit being typified by lamps rather than by motors.

If the machines are close to the switchboard, the equalizer connection may be placed there in common with the rest of the fittings; but it is essential that this wire be of very low resistance, and rather than use long leads, it is good practice to mount single-pole switches on each machine, and let the length of conductor be as short as possible. In the first case, triple-pole main switches would be used on the switchboard, in the other, ordinary double-pole switches, or for specially large currents, two similar ones of single-poles.

For properly connecting an additional compound generator in parallel with others that may be running, the voltage across the line is first read, then by means of the field rheostat the new machine is adjusted to the same pressure. The equalizer switch may have been closed when the engine was started; at any rate, it must now be closed. As soon as the main switch, too, is closed, the equalizer action begins, but the machine will not assume its proper share of the load until adjusted by use of the rheostat. Though the compounding will enable a proper sharing during the normal run, the rheostat is essential in initial and final steps.

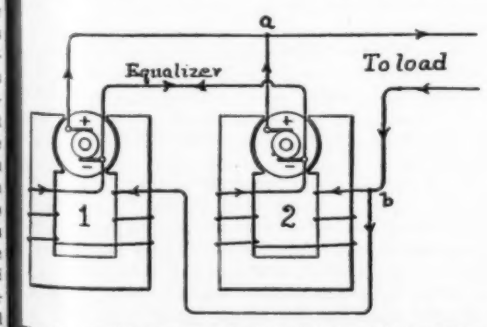

Fig. 46.—Series Dynamos in Parallel—Equalizing Wire.

When accurately proportioned and driven by well-regulated engines, compound generators yield a uniformity of potential that is almost marvelous. Yet, as with many other good things, there is an accompaniment of actual danger, and this possibility is so marked that for years the Edison Company refused to build machines of this sort, and in many modern stations large shunt generators have been installed or the compound ones changed to the simpler sort. The danger is found in the fact that if, by accident, the potential of one machine falls too low to be corrected by the equalizing current, the main current from the others will flow backward through its series coil, reverse the polarity, and make the machine a helpless short circuit to the rest of the station. Of course, in such a contingency, it would be expected that fuses, circuit breakers, or other safety devices would come to the rescue, but even if the machine were not "burned out," serious scars would somewhere be visible, and undesirable interruption of the service take place. Storage batteries constitute an ever-present menace of such a disaster, and many expensive accidents can be charged up to their connection with compound generators. With plain shunt machines, a back current from battery would simply change the machine into a motor, running in the same direction as before, and helping the engine. To prevent injury to the battery, however, due to possible abnormal or unnecessary discharge, underload switches are usually put in circuit, which automatically open in case of a certain minimum current. If they could always be depended upon, of course they would forestall such reversals of polarity as has been mentioned.

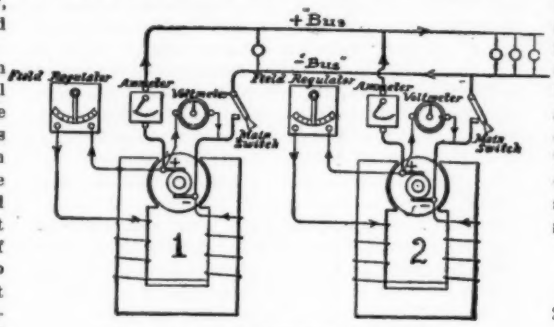

Fig. 47.—Shunt Dynamos in Parallel.

Shunt and compound generators are also used in pairs, connected in series, for operating the Edison three-wire system. By properly combining the ideas already given, the reader can easily make the diagrams of connections. A suggestion can be gained from reference to Fig. 43 of Chapter XI. Actual switchboard arrangements will be given in later chapters.

The parallel running of alternating-current dynamos involves special difficulties, at first thought to be insuperable, but their overcoming is one of the most notable triumphs in dynamo design and in delicacy of switchboard manipulation.

With Chapter XIII. a beginning will be made in explaining the principles of alternating currents. The subject is by no means easy to expound, but the serious reader will be put in touch with that which is both fascinating and marvelous. It forms the real gist of electrical engineering.

LEATHER VARNISHES.

LEATHER varnishes serve two purposes—either to make natural leather into patent leather, by giving it a glossy coating, or to produce a glossy surface upon worked and used leather or to renew it. The varnishes used to produce patent leather are of subordinate importance, and will not be treated of here. The others are of greater value, and deserve more detailed consideration.

We may distinguish water varnishes and volatile varnishes, but we will treat here simply of the latter, which consist of solutions of luster-giving substances in volatile mediums. It is necessary that they should dry quickly, and the thin coat of varnish which remains must be as elastic and pliable as possible, so that the leather can be bent or folded without injury to the glossy surface.

Solutions of shellac, amber, and copal produce a very fine luster, but the coat of varnish is too hard and has but little elasticity; amber and copal, moreover, are not easily dissolved in any of the mediums which enter the question here, without previous preparation. For this purpose they must be roasted or distilled (hardened). Shellac, in spite of its ready solubility in alcohol, makes cloudy solutions, on account of its contents of wax, and the solutions must either be filtered or cleared by long standing; nevertheless, shellac is extensively used for leather varnishes. Among soft resins, sandarac, elemi, mastic, benzoin, Dammara resin, and, of late, acaroid resin, are used; but some of these do not dissolve perfectly in the mediums, and the coatings which they give, though pliable, have little power of resistance. Colophony (rosin) is a material of little value for leather varnishes, and is used only in combination with other less brittle and more durable resins. Colophony is hardened by heating with metallic oxides to about 200 deg. C. Natural and also artificial (tar) asphalt is worked up into cheap leather varnishes. Other raw materials for volatile leather varnishes are India rubber, used in freshening up rubber overshoes; tannin, in the form of tannic acid, to give gloss (this is, however, soluble in water); turpentine, to increase the pliability of the coat; and drying oils, such as linseed and castor oil, to make it more elastic; turpentine oil and rosin oil, which also increase the elasticity of the coat, but delay the drying. Quick-drying leather varnishes contain, as dissolving mediums or solvents, gasoline, benzol, carbon disulphide, alcohol, and sometimes sulphuric ether or petroleum ether; these mediums evaporate quickly, and leave a thin coat of the resin upon the leather. Aniline colors which are soluble in alcohol or oil are used for coloring the varnishes, also lampblack and other substances.

According to the desired character and price of the leather varnish—better or poorer, harder or softer—the raw materials are chosen, and the manufacturer needs experience to enable him to find the correct mixtures. The hard substances are pulverized as thoroughly as possible, and dissolved by shaking in large bottles or in a shaking cask, or by careful heating in a special apparatus; and the resinous solutions, as concentrated as possible, are drawn off into storage casks. The desired varnishes can then easily be produced by dilution, mixing, and coloring. Black and colored spirit varnishes for leather, made from shellac, are in great demand, and extensively used.

Some formulas for volatile leather varnishes follow:

Glossy Black Leather Varnishes.

1. 500 parts 95 per cent alcohol, 70 parts shellac, 20 parts turpentine, 10 parts spirit-soluble nigrosin.

2. 500 parts 95 per cent alcohol, 90 parts shellac, 15 parts sandarac, 10 parts turpentine, 6 parts castor oil, 12 to 15 parts spirit-soluble nigrosin.

3. 500 parts 95 per cent alcohol, 70 parts shellac, 30 parts colophony, 10 parts rosin oil, 10 parts turpentine, 10 to 15 parts spirit-soluble nigrosin.

4. 500 parts 95 per cent alcohol, 60 parts shellac, 25 parts sandarac, 15 parts colophony, 25 parts turpentine, 15 parts turpentine oil, 12 to 15 parts spirit-soluble nigrosin.

Dull Black Leather Varnish.

500 parts 95 per cent alcohol, 125 parts shellac, 15 parts wax, 10 parts turpentine, 10 to 15 parts spirit-soluble nigrosin.

Light-Colored Shellac Varnish.

500 parts 95 per cent alcohol, 100 parts bleached shellac, 20 parts turpentine, 15 parts turpentine oil.

Coloring Material.

7 to 8 parts metanil yellow, 10 to 12 parts cerotin orange, 10 to 15 parts brilliant crocein (for red), 10 parts Bismarck brown.

Copal Varnishes.

1. 500 parts 95 per cent alcohol, 50 parts Manila copal, 50 parts sandarac, 20 parts turpentine, 10 parts nigrosin.

2. 500 parts 95 per cent alcohol, 65 parts Manila copal, 20 parts sandarac, 20 parts acaroid resin, 10 parts elemi, 10 parts turpentine, 10 to 15 parts spirit-soluble nigrosin.

Acaroid-Resin Varnish.

500 parts 95 per cent alcohol, 150 parts acaroid resin, 25 parts turpentine.

Benzoin Varnish.

500 parts 95 per cent alcohol, 150 parts benzoin resin, 20 parts turpentine.

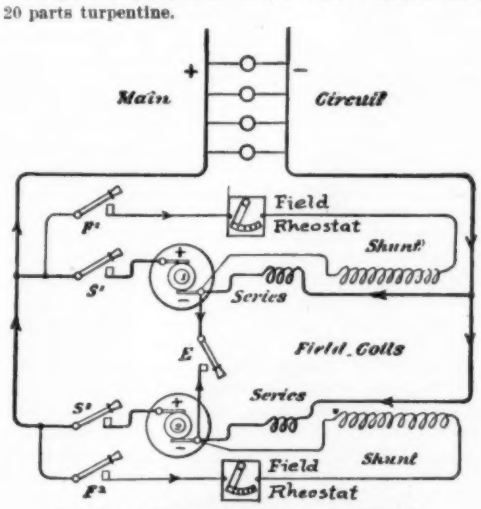

Fig. 48.—Compound Dynamos in Parallel

Black Asphalt Varnish (Cheap).

1 part asphalt dissolved in 6 or 7 parts of benzol by shaking.

Tannin Varnish.

20 parts 95 per cent alcohol, 1 part turpentine, 4 to 5 parts tannin.

Varnish to Freshen Russia Leather.

500 parts 95 per cent alcohol, 60 parts sandarac, 40 parts shellac, 10 parts turpentine, 10 parts birch-tar oil. Coloring, nigrosin for black, fuchsin for red.

Artificial bitter almond oil (nitro-benzol), lavender, or rosemary oil are sometimes used to perfume these volatile leather varnishes.—Abstracted for the SCIENTIFIC AMERICAN SUPPLEMENT from Der Chemisch-Technische Fabrikant.

WHAT IS MATTER?*

THE INVESTIGATIONS OF MODERN PHYSICISTS.

BY PROF. L. E. MEZGS.

NEARLY two and a half centuries ago, in 1658, to be accurate, Boscovich, the great Italian administrator, diplomat, and physicist, set forth and ably defended the view that atoms are but forces, each concentrated in a mathematical point, and held apart by their mutual repulsions. The view did not fail of its adherents, numbering among them names as great as that of Faraday. But even if the prejudices of an imaginative race had allowed it a fair hearing, which they did not, the state of science was not ripe for the general acceptance of the theory. Electricity did not exist for science, and countless hours of research had still to be labored through before a sufficient weight of experimental facts could be accumulated to outbalance our tribal idol. So stiff-necked is an inborn bent of human nature. Besides, Boscovich delayed the triumph of his theory, in its essential principle, in my judgment, by confining his force atoms to mathematical points, and denying them spatial occupancy, the fundamental attribute of matter: a course the more to be regretted, as the denial is unnecessary, indeed contrary to plain experience.

The status of Boscovich's theory, and its more or less modified successors, remained practically unchanged till the end of the nineteenth and the marvelous beginning years of the present century, a few of the best minds of each generation upholding it, but the large majority of physical scientists, including men of unsurpassed eminence, according it a neglect more or less contemptuous. But these recent years have been bringing about a change. A number of physicists of the first rank are championing the dynamic theory of matter, and as each unexpected discovery, hurrying upon the heels of its predecessor, brings support to the theory, its opponents seem conscious of engaging in a losing fight.

Before passing to the chief evidence, I will just mention some curious experiments of the Hindu physicist, Dr. Bose, a professor in Calcutta University, which indicate the trend of the more advanced research that is now being prosecuted, and indirectly support the dynamic theory, by tending to show that metals, at least, are not dead, but alive, bundles of activities like living animals. Dr. Bose's book, "The Response of Matter," I have not been able to secure; the quotation that follows is from a notice of it in the London Review of Reviews. Dr. Bose's discovery is, that stimulated metals give back, under proper conditions of observation, the electric response that has been thought peculiar to, and characteristic of, organic or living matter, and, with variation of conditions, vary their response just as organic matter does.

"When the metals were stimulated by a pinch they also made their autographic records by electric twitches, and thus, being responsive, showed that they could in no sense be called 'dead'! Nay, more, it was found that given the records for living muscle, nerves, and metals, it was impossible to distinguish one record from another. For the metals also, when continuously excited, showed gradual fatigue; as with ourselves, so with them, a period of repose revived their power of response—even a tepid bath was found helpful in renewing vigor; freezing brought on cold torpidity, and too great a rise of temperature brought heat rigor. . . .

"Death can be hastened by poison. Then can the metals be poisoned? In answer to this was shown the most astonishing part of Prof. Bose's experiments. A piece of metal which was exhibiting electric twitches was poisoned; it seemed to pass through an electric spasm, and at once the signs of its activity grew feebler, till it became rigid. A dose of some antidote was next applied; the substance began slowly to revive, and after a while gave its normal response once more."

But it is not upon such experimental curiosities that the dynamic theory of matter is based, significant as they may be of the future discoveries of science. It is more substantially founded upon the evidence of the spectroscope, the fast-growing knowledge of electricity, and the marvelous results of the experiments on radio-active substances. Recent publications have made these facts familiar, and it will only be necessary to recall them briefly, grouping them in such wise as to suggest their significance as clearly as possible.

There has been a disposition among scientists for the last half century, growing constantly stronger, and finally becoming nearly irresistible, to look upon Dalton's atoms as divisible, therefore misnamed, and not the ultimate constituents of matter. Suspicion was first cast upon their simplicity and ultimateness when the spectroscope disclosed several distinct lines in the spectrum of each element; and was reinforced when it appeared that some elements had two or even three distinct spectra. Nor was the case bettered when it was found that many of the lines in the spectra of hydrogen, calcium, iron, and other elements are missing when the light from very hot stars is broken up. For the inference is right at hand, as Prof. Bigelow says, "that at extreme, at stellar temperatures, our elements themselves are dissociated into simpler substances."

Further evidence against the atom resulted from Prof. J. J. Thomson's studies of cathode rays, strict reasoning from his careful experiments demonstrating them to be swarms of minute particles, or corpuscles, as he called them, moving with velocities approaching that of light, and each weighing about one eight-hundredth as much as a hydrogen atom. These corpuscles are not merely ordinary atoms of smaller bulk, for they do not obey chemical laws, it having been ascertained, among other things, that the absorption of them by different substances is simply proportional to the latter's specific gravity, and quite independent of their chemical properties.

And recently the case against the atom, together with Thomson's ingenious demonstration of his corpuscles, has secured further experimental foundation, thanks chiefly to the labors of Becquerel, the Curies, and Rutherford and Soddy, on radio-active substances. These wonderful experiments, at once rapid and reliable, have shown that radio-activity consists in the throwing off of two orders of substances: first, atoms, second, rays or corpuscles of various kinds. But the remarkable fact in the situation is that while the atomic weight of the original substances, radium, thorium, and uranium, is two hundred or more, the weight of the atoms thrown off is nearer one or two. That is, radium breaks up into, probably, helium, thrown off, and the residuum after the emission, which has a different atomic weight from either and is otherwise shown to be a distinct element. The dream of the alchemist has come true, and elements are transmuted before our eyes. Science has achieved an unsurpassed triumph! But, as far as helping us to fortune goes, the dream might as well have remained a dream.

As a result of these discoveries, and many others similar, in general, in significance, it has come to be admitted that Dalton's atoms are very complex bodies, each made up of a large number of corpuscles, which are related to one another very much as are the members of a planetary system, though in size corpuscles are unimaginably minute, and the number of them constituting any atom is very much larger than the number of members in any planetary system with which we are acquainted.

With atoms broken up into corpuscles, the problem of the nature of matter shifts one step farther back, and becomes the problem of the nature of these tiny bodies. Of this problem two rival solutions are now in the field, offered respectively by the conservatives and the liberals. The former, while admitting that a corpuscle is in the main an electric charge, or field of electric force, maintain that the charge has a nucleus or carrier at its core, which alone is entitled to be called matter, in distinction from the electricity of the charge. Lenard, who has given to corpuscles the significant name of dynamides, has calculated the diameter of this center of actual matter, so called, and found it to be smaller than 0.3 of 10^{-10}, *i. e.*, smaller than three hundred thousand millionths of a millimeter. This means that the actual matter, so called, of a cubic meter of so heavy an element as platinum, occupies at most one cubic millimeter of space, the rest of the cubic meter being empty of Lenard's matter, and in fact entirely empty of ponderable matter, but for the electric charges.

With so much of matter acknowledged to be electric force, which to that extent successfully performs all the functions which used to be attributed to matter, it is natural, say the liberals, to inquire whether the whole of matter cannot be reduced to force, whether matter is not just force and nothing more. Many facts, they say, make this altogether the more probable, indeed the only comprehensible, hypothesis.

In the first place, as Sir Oliver Lodge, who shares with Prof. J. J. Thomson—another hard-headed Englishman—the distinction of leading the liberals, points out, "an electric charge possesses the most fundamental and characteristic property of matter, viz., mass or inertia." If the charges occupying a given space are sufficient, and their potential is sufficiently high, their combined mass will equal, and exhaustively account for, the observed mass of the matter occupying the space. This conclusion was theoretically established long since, and has recently received experimental confirmation from laboratory studies on radio-activity.

On these points, I quote the statement of Prof. Bigelow, of the University of Michigan:

"Long before experimental evidence of the existence of corpuscles had been obtained, it was demonstrated that an electrically charged body, moving with high velocity, had an apparent mass greater than its true mass, because of the electrical charge. The faster it moved the greater became its apparent mass, or, what comes to the same thing, assuming the electrical charge to remain unaltered, the greater the velocity the less the mass of the body carrying the charge needed to be to have always the same apparent mass. It was calculated that when the velocity equaled that of light, it was not necessary to assume that the body carrying the charge had any mass at all! In other words, the bit of electric charge moving with the velocity of light would have weight and all the properties of mass.

"This might be looked upon as an interesting mathematical abstraction, but without any practical application, if it were not for the fact that Kauffmann determined the apparent masses of corpuscles shot out from a radium preparation at different velocities, and compared them with the masses calculated on the basis that the whole of the mass was due to the electric charge. The agreement between the observed and calculated values is so close that it leads Thomson to say: 'These results support the view that the whole mass of these electrified particles arises from their charge.'

"Then the corpuscles are to be looked upon as nothing but bits of electric charges. . . . It is this view which has led to the introduction of the term electron. . . . We have but to concede the logical sequence of this reasoning, all based on experimental evidence . . . and we have a universe of energy in which matter has no necessary part."

Facts as many and as significant as these, added to the reasoned conclusions of philosophy and psychology, would seem adequate to settle the controversy in favor of the dynamic theory of matter, were it not that we are dealing with an idol of the tribe, far more difficult to shatter than the golden calf. But more remains to be said. The validity of a hypothesis rests not only upon the facts that support it, but also upon the ability it gives us to explain puzzles in fields adjacent to its own. This makes it worth while to mention, though space will not allow explanations in detail, that a number of knots in physical theory, that before had to be cut or else left alone, can be handily untied by the dynamic hypothesis. Prof. Bigelow is again my authority in the statements, that the theory explains the highly puzzling property of valence, and that "an electronic structure of the atom furnishes a basis from which a plausible explanation of the refraction, polarization, and rotation of the plane of polarized light may be logically derived. These explanations bulk large in the aggregate, and the exclusive ability of the dynamic theory to make them adds significantly to its credibility.

As an alternative to the dynamic theory, thus substantially supported, the conservatives have little to offer, indeed, in the last analysis, nothing but a word. The "matter" they refuse to identify with force shrinks down to John Locke's "something, I know not what," by which a portion of the mass of bodies is to be accounted for. But, Sir Oliver Lodge remarks: "It would be equally true to say unaccounted for. The mass which is explicable electrically is to a considerable extent understood, but the mass which is merely material (whatever that may mean) is not understood at all." "What is this matter which so many insist we must assume?" Bigelow asks, and answers:

"No man can define it otherwise than in terms of energy. . . . Starting with any object and removing one by one its properties, indubitably forms of energy, we are finally left with a blank, a sort of hole in creation. . . . The last resort is the time-honored definition, 'matter is the carrier of energy,' but it is impossible to describe it. The assumption that matter exists is made then because there must be a carrier of energy. But why must there be a carrier of energy? This is assertion, pure and simple, with no experimental backing."

* Abstract from the Presidential Address before the Texas Academy of Science.

When solidity, and mass or inertia are adequately explained as dynamic facts, and many puzzling physical facts are similarly accounted for, it is surely superfluous to seek further explanation in something more to be called matter, especially when no man can tell or ever has told us what he means by the word.

This is not the place to set forth what we know about electric charges, but some mention should be made of the unification introduced into our knowledge by accepting these minute bodies as the building stones of the grosser structures more immediately experienced.

A word first as to their size:

"We are sure," says Lodge, "that their mass is of the order one thousandth of the atomic mass of hydrogen, and we are sure that if they are purely and solely electrical their size must be one hundred thousandth of the linear dimensions of an atom: a size with which their penetrating power and other behavior is quite consistent. Assuming this estimate to be true, it is noteworthy how very small these electrical particles are, compared to the atom of matter. . . . If an electron is represented by a sphere an inch in diameter, the diameter of an atom of matter on the same scale is a mile and a half."

He proceeds a little later:

"It is a fascinating guess that the electrons constitute the fundamental substratum of which all matter is composed. That a group of say 700 electrons, 350 positive and 350 negative, interleaved or interlocked in the state of violent motions so as to produce a stable configuration under the influence of their centrifugal inertia and their electric forces, constitute an atom of hydrogen. That sixteen times as many, in another stable grouping, constitute an atom of oxygen. That some 16,000 of them go to form an atom of sodium; about 100,000 an atom of barium; and 160,000 an atom of radium.

"On this view all elements would be regarded as different groupings of one fundamental constituent. Of all the groupings possible, doubtless most are so unstable as never to be formed; but some are stable, and these stabler groupings constitute the chemical elements that we know. The fundamental ingredient of which, on this view, the whole of matter is made up, is nothing more or less than electricity, in the form of an equal number of positive and negative electric charges.

"This, when established, will be a unification of matter such as has through all the ages been sought: it goes further than had been hoped, for the substratum is not an unknown and hypothetical protyle, but the familiar electric charge."

And having gone thus far, we cannot escape going farther. For two or more atoms, properly related, form molecules; these groups of forces, aggregated in large numbers, form, on the one hand, masses of inorganic matter, and, on the other, living cells; and the last, in turn, organize themselves into living, and ultimately into conscious and rational, beings, who, in the last resort, are vastly complicated activities, aware of, and in a measure controlling, their own intricate behavior. To an active imagination the dynamic theory opens up fields fascinating to contemplate. Look first at the practical side. Aside from energy of gross position and molar motion, we are accustomed to think of heat and other forms of chemical energy as the only ones available for human use. But Wetham tells us:

"As a mean value, we may say that, in mechanical units, the energy available for radiation in one ounce of radium is sufficient to raise a weight of something like ten thousand tons one mile high."

And later that:

"The energy liberated by a given amount of radioactive change . . . is at least 500,000 times and may be 10,000,000 greater than that involved in the most energetic chemical action known."

Admitting that our coal measures and iron mines may in time give out, it is evident that the present generation need not feel greatly alarmed. For who will deny to ingenious man the ability to harness these literally stupendous new forces as he has their weaker predecessors?

And on the theoretical side the gain is no less great. A respectable hypothesis, which experimental and even laboratory methods can test, correct, and enlarge, as growing experience demands, can, even in its initial form, give unity to our thinking. It not only reduces the independent chemical elements to brotherhood in the one mother substance, but it renders matter, as essentially activity, homogeneous with active mind, thus freeing us from the hopelessness of dualism, and giving a monistic view of the whole of things. And nowhere is utter death to be found. The universe, active through and through, comes out from under the heavy hand of rigid mechanism. Spontaneity is at its heart, and in the marrow of its bones. But lawless and chaotic it is not. There is regularity in the operation of its minutest parts, and organization, harmonious co-working, is the law of its being, from the co-operative union of electrons into atoms to the organization of men into societies, and possibly farther still. But the order and harmony are not imposed from without by an alien power; as the laws of children's play, they are the natural rules of behavior of spontaneous beings, following, unhampered by others besides themselves, the promptings of their interacting natures.

ATMOSPHERIC NITROGEN.*

ITS FIXATION BY PLANTS.

BY W. J. UGLOW WOOLCOCK.

PROF. BOTTOMLEY, the professor of botany at King's College, London, has been investigating the absorption of nitrogen from the air by plants, and on its fixation in the soil in a form suitable as a plant food. In agricultural operations large quantities of nitrogen are removed from the land in harvesting in the form of nitrates, which the plant has built up during the process of its growth. In consequence of this need for nitrogen by the plant, manuring with nitrogen-containing products becomes one of the most necessary conditions of successful agriculture. The construction of nitrates from ammonia and nitrites has long been a familiar process, but for many years the free nitrogen of the air, owing to its chemical inertness, was deemed of no service to the plant organism. Under certain conditions, however, fixation of atmospheric nitrogen has been conclusively proved during recent years, and both practically and theoretically it is a phenomenon of the very greatest importance.

The Leguminosæ have long played a special part in agricultural processes; not only because they grow in sterile sandy soils without any addition of nitrogenous manure, but because they actually improve such soils and make them suitable for the growth of plants which do not belong to that family. The fact that the growth of a leguminous crop was the best possible preparation for the subsequent raising of a vigorous wheat crop was noticed by farmers, but the explanation was not so patent. High scientific authorities, both in this country and on the Continent, were engaged in the elucidation of this problem, but for many years without definite result.

It was in 1888 that Hellriegel and Wilfarth announced their discovery that the nodules on the roots of leguminous plants were caused and inhabited by living organisms, which utilized the nitrogen of the air and supplied the same to the plant in an available form. Hellriegel and Wilfarth in their classic experiments planted certain Leguminosæ (peas and lupins) in very pure quartz sand, which had been previously freed from all micro-organisms by sterilization. Certain cereals (oats and barley) were treated in the same way. In each case it was found that growth took place only on the addition of nitrates. A very important difference was noticed, however, as soon as a small quantity of an extract of arable soil had been added to the sterile soil free from nitrates. The Leguminosæ showed a remarkable gain in nitrogen which could only have arisen from the employment of atmospheric air, but in the case of cereals the addition of the soil extract produced no result.

The effect of the soil extract must have been due to the activity of micro-organisms present and not to the amount of nutrient which it contained, since, on heating it to a temperature of 70 deg. C., the effect was nullified. Again, the organisms must be such as have special relationships with the Leguminosæ, since there was an absence of any result in the case of the cereals. Further, it was shown that *different* Leguminosæ require *different* micro-organisms, since the extract of a soil in which peas had been cultivated, but in which no lupins had ever been grown, furthered the growth of peas only, and not of lupins.

Thus, Hellriegel and Wilfarth showed in the clearest way that the micro-organisms present in the soil extract were the cause of the formation of the nodules on the roots of the Leguminosæ, and that these plants could assimilate atmospheric nitrogen only when the micro-organisms were present in the root nodules. Also, they showed that it is not sufficient merely that any kind of lower organism should be present in the soil, but that it is essential that *certain species* of the latter should first of all enter into symbiotic relationship with the leguminous plant. The nodules are formed by bacteria known collectively as *Bacillus radicicola*.

These bacilli enter the cells of the root, and there increase to an astonishing degree. The stimulation produces local hypertrophy in the cells just as in the case of gall formation. In the majority of the cells of the nodule are found masses of the bacillus, which afterward degenerate and exhibit branched involution forms rich in proteid. These involution forms are finally broken down and employed by the plant as proteid reserves, but only a part of the bacilli become thus altered and sacrificed to the good of the leguminous plant, the rest persist, and, after the degeneration of the nodule, they remain in the soil and serve to infect the next year's plants. Since the bacilli yield nitrogen to the leguminous plant, and the latter yields carbon in an appropriate form to the bacilli, the union of the two organisms is a case of true symbiosis.

Thus the matter rested, so far, at least, as experiments in this country were concerned, until Prof. Bottomley took the matter up. In 1906 and 1907 over a thousand packages of cultures of bacilli were distributed free over the United Kingdom from King's College, with the object of thoroughly inoculating the roots of the leguminous plants in the fields. The reports sent in by farmers and gardeners show that a markedly increased crop resulted in 80 per cent of the cases in which the bacillus culture had been used. At the present time plants other than leguminous are being experimented with in the laboratory. Prof. Bottomley has been able to produce new forms, or rather physiological varieties, of the first discovered bacillus, which are capable of symbiosis with various other green plants. These new varieties of bacilli are able to fix atmospheric nitrogen, and supply nitrogen compounds to the various plants which Prof. Bottomley has infected with them.

In one series of experiments the *Bacillus radicicola* was "starved"; the bacilli were taken away from their favorite food, the leguminous root, and bred for ten generations in an extract of tomato roots. The new descendants are reported to have acquired a taste for their new food, and the result of "sowing" the soil in which tomatoes were grown with the bacilli was the occasional formation of nodules, and the very marked improvement of the crop. Similar treatment has been followed in the case of cereals, roses, cabbages, and strawberries. In every case the yield has been improved, and the soil enriched.

The fact that so few cases of the symbiosis of nitrogen-fixing bacilli with the roots of green plants should be found in nature has been remarked by Prof. Vines. Apart from the leguminous plants, root tubercules have been observed only in a few cases, notably the alder, *Eleagnus*, and some few gymnosperms. Thus there is, apparently, a limited number of green plants adapted to certain bacilli, and certain bacilli adapted to live in the roots of certain green plants. The question arises: Why is the number so limited? Why is there not an adapted bacillus for every green plant? Prof. Bottomley's experiments go to prove that by suitable cultivation the symbiotic bacillus of one plant may be adapted to become the symbiotic bacillus of another plant. This adaptation has surely been going on for ages in nature, since there are evidences of similar adaptations to be found in every direction. "Yet," as Prof. Vines writes, "Nature seems to have been less successful in her operations than Prof. Bottomley—it would be interesting to know exactly how and why."

The supply of nitrates available for spreading over the soil is necessarily limited. A few years ago the discovery of a means whereby the nitrogen of the air could be made to combine with oxygen and hydrogen to form nitric acid was hailed with enthusiasm, despite the cost of the electrical method whereby it was produced. To-day it appears probable that the chemist will no longer be called upon to supply the nitrates that the soil needs. The property of nitrogen fixation thought so many years to belong to but one order of plants, will, perhaps, be shown to be common to not only a few isolated orders, but to the whole vegetable kingdom. A process of nitration will go on silently beneath the cover of the soil.

* From the Pharmaceutical Journal.

THE ASCENT OF SAP IN PLANTS.

By DR. OTTO N. WITT.

THE ascent of sap in plants is commonly regarded as one of the unsolved mysteries of nature. By what power can a tree raise sap—that is to say, water—to its topmost leaf, a hundred feet above the ground? All sorts of theories have been proposed to account for the phenomenon and it has even been attributed, very conveniently, to the action of a peculiar and yet undiscovered force.

Yet the solution of the problem is very simple. It is suggested by the fact that if a bunch of cut flowers, with stems of various lengths, is placed in a vase with water, the flowers whose stems do not reach the water quickly wilt, while the long-stemmed flowers remain fresh.

The force that causes sap to rise in plants is the force that causes water to rise in pumps—the pressure of the air, which is equal to the pressure exerted upon the bottom of a vessel by a column of mercury 30 inches high, or a column of water about 34 feet high.

Sap rises in plants, however, to heights much greater than 34 feet. Hence it has been concluded that the atmospheric pressure does not suffice to account for the phenomenon. This objection will be considered presently.

When the piston of a pump is raised a partial vacuum is produced below it, and the water in the pipe, impelled by the pressure of the air on its free surface, raises the seat valve and flows into the pump barrel to fill the void. Plants, having no pumps with valves and pistons, create a vacuum by the evaporation of water from their surfaces, aided by the elasticity of their cell walls.

The walls of vegetable cells are composed of cellulose and they constitute ideal dialytic membranes. When moist, they allow liquids to pass through them but do not allow gases to pass unless the gases are dissolved in liquids. The cell walls, furthermore, are elastic and approximately spherical or cylindrical—that is to say, they have a form which offers a maximum resistance to deformation by pressure from outside. When such a cell, filled with watery sap, is exposed to the air, its aqueous contents exude through the cell wall and evaporate, but the outer air cannot pass through the wall to take the place of the water that is lost. Hence there are only two possibilities. Either the cell is deformed and crushed by the external pressure or it is refilled with fluid drawn from neighboring cells. The latter are compelled to supply their losses in the same way and so the action extends until a source is reached capable of supplying sufficient water to replace that lost by evaporation. This occurs in plants growing in moist soil and also in cut flowers with their stems immersed in water. If the supply of water fails in either case the cells are deformed by the pressure of the atmosphere. In other words, the plants or flowers wilt.

This is the simple explanation of the upward flow of sap in plants, either rooted or cut, for there is no physiological difference between the two. A cut branch is not like an animal deprived of a vital organ, for in time it can replace its lost root, as experience in the propagation of plants from cuttings proves. Twigs of ivy, willow, and oleander put forth roots even when their ends are simply immersed in water. It is true that most cut flowers soon wither and die even when supplied with water, but this result is due to secondary causes, like bacterial poisoning and lack of nutriment, which do not concern us at present. Except for the operation of these causes cut flowers would remain fresh for a very long period if abundantly supplied with water, and as a matter of fact many orchid blossoms can thus be kept fresh for weeks.

But how can we explain the rise of sap in plants to heights greater than 34 feet, the greatest height to which water can be raised by a suction pump?

In the first place, the limit of 34 feet does not apply to the ascent of water in narrow tubes. In the exceedingly fine vessels of plants there is a very appreciable capillary elevation, an idea of which may be gained by suspending a long strip of linen or muslin in a vertical position, with its lower end dipping in water, and observing that the strip becomes wet for more than a yard above the water's surface.

The sum of the capillary elevation and the height of the water barometer, however, is very much less than the height to which sap ascends in tall trees. But there is another important factor—the solubility of gases in aqueous solutions. In the vital processes of the plant itself, gases are formed which are at first dissolved in the sap but gradually separate in the form of minute bubbles. A large quantity of air also penetrates into the cells from without in dissolved form. When living vegetable tissue is examined with a microscope it is always found to be filled with little bubbles of gas. Such a foamy mixture of sap and gas must be much lighter than water, and it is consequently raised to a far greater height by the pressure of the atmosphere.

Even this increased height has a limit, which determines the maximum height which plants can attain. Vines with nearly horizontal stems are not thus restricted and may extend to lengths far exceeding the heights of the tallest trees.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Prometheus.

TRADE NOTES AND FORMULÆ.

Champlevé Enamel.—By means of steel punches, hollows are struck in thin sheet gold, these are filled with enamel, which is fused in.

Adhesive Labels for Sticking on Glass, Porcelain or Iron.—1,200 parts of gum arabic and 300 parts of gum tragacanth, dissolved in water, mixed and strained; to this add 1,200 parts of glycerine mixed with 25 parts oil of thyme. Make up the solution to 10,000 parts with water.

Marking of Casks and Boxes.—(*a*) (according to Campe). Black made by boiling borax and shellac, sufficient lamp-black being added to the mixture. (*b*) Solution of 10 parts gum arabic, 1 part soda and 1 part glycerine with about 40 parts of water, with a sufficient quantity of lampblack, gives a nice, durable, marking paste.

Production of Scented Fish Bait.—For moistening the bait, we need, according to Pharmazeutische Rundschau, the following preparations: (1) Peruvian balsam, 1.0; oil of mirbane (nitro-benzol), 1.0; anhydrous alcohol, 4.0. (2) Musk, 0.05; civet, 0.25; Peruvian balsam, 4.0; oil of aniseed, 1.5. (3) Extract of fresh "broad bean" leaves, 10 to 150, mixed with 10.0 of nitric ether, and 1 drop of volatile animal oil. (4) Especially for trout, civet with red-wood oil.

Colored Lead Pencils.—Faber receipt (Stein, near Nuremberg).

	Very Soft.	Soft.	Hard.	Very Hard.
Aniline dyestuff.	50	46	30	25
Chemically prepared graphite	37.5	34	30	25
Purified kaolin..	12.5	20	40	50

The materials, pulverized as finely as possible, are mixed with water into a paste, of which little sticks are formed.—Bersch.

Ornamentations on Ivory.—The object is coated with a suitable ground which is engraved as desired and the drawing etched in with the aid of the following fluid: 9 parts of nitrate of silver in 40 parts of distilled water. The fluid is allowed to work for about half an hour, then it is dried off with blotting paper and the etched surface exposed at once to the sunlight. Other colors are obtained by means of chloride of gold or chloride of platinum, in place of silver in the above solution.

To Cover Threads with Metal and Smooth Them.—The previously colored and boiled-out threads, especially silk threads, are sufficiently softened and wetted in a 0.5 per cent solution of gelatine in water. The threads are gently pressed out, saturated with water containing 0.25 per cent of dissolved gelatine. In this they are allowed to lie for a time, whereupon they are dried and passed through a solution of wax in benzine. After drying it is wound on rolls. The threads are then drawn through a solution of 2 parts acetate of lead (sugar of lead) and afterward, through a long glass tube, through which a current of sulphureted hydrogen is passed. This imparts to the threads a very beautiful, dark, silver-gray color.

Enameling Cast-Iron Objects.—Ground preparation: 50 parts by weight of quartz, finely ground and dry, 25.5 parts of borax, not freed from water, 7.5 parts of fluor-spar, finely stamped and ground, altogether 80 parts. This mixture is fused together in clay crucibles and yields 68.5 to 69 parts by weight of fused mass, which is freed from all earthenware particles, cleansed, beaten, and stamped. Of the stamped mixture 16 parts are taken and mixed dry with 6.5 to 12.5 parts of quartz (usually 12.5 parts), 4 to 6.5 parts of gray clay (usually 4 parts), and 0.5 part of borax. This new mixture is ground in the wet-mill and to each such quantity, which just suffices to fill a mill, is added 2.5 parts of clay and 0.66 part of borax. The ground mixture is brought to the proper consistency, either with water or with clay paste made with water, then applied, dried, and burned. The again cooled articles are now provided with a so-called covering mass, which must also be applied wet in the form of a fine slime. The covering mass consists of the following: A dry mixture is made of 2.5 parts of fluor-spar, finely stamped; 1 part of commercial oxide of zinc; 4.75 parts of oxide of tin as furnished by the calcining furnaces; 0.75 part of powdered bone (commercial quality), 0.03 to 0.05 part of smalt. This mixture, making 9 to 9.25 parts by weight, is sifted. Later, with every 9 to 9.25 parts of it, 16 parts of finely ground felspar is mixed, 9.5 to 9.75 parts of borax, not anhydrous, 3.25 parts of soda, not anhydrous, 1.25 to 1.5 parts of nitrate of potash. This is all melted together in fireproof crucibles, having a hole at the bottom, the molten mass flowing out of the hole into a receiver placed beneath the furnace grates. The cooled mass is again coarsely broken, at the same time freed from impurities present and stamped. Of the stamped mass 30 parts at a time are transferred to the wet mill and to each such batch are added 6 dishes, each holding about 140 parts of white clay, carefully mixed with water, and 0.3 parts of oxide of zinc. The finished mass is brought to the proper consistency applied to the ground mass and burned in.—Bersch.

ENGINEERING NOTES.

There is at present a general tendency to centralize power, heating, and gas plants. In the heating of buildings it is customary under existing conditions to generate steam in the building. Where this is done, it is in general considered more economical to install engines for generating current for light and power also. However, many buildings furnish their own heat, but purchase current. Large power or light plants can now be located at any convenient place, say at the coal mines, because of the ease and economy with which electric current can be transmitted; but heating plants, whether for residence or for business districts, must be within a comparatively short distance from the section to be heated on account of the cost of installation and the losses from radiation. There are now more than 150 central heating plants in the United States, furnishing steam or hot water to residences or business buildings or to both. The greater number of these plants are located in the coal-producing States.

The largest engine in the world will shortly be erected at the Sharon, Pa., works of the Carnegie Steel Company. Two of the castings weighed 118 tons each after machining and special flat cars were built for their transportation. The engine, which has a capacity of 25,000 horse-power, weighs when set up 550 tons without foundation plates or flywheel. It is a horizontal twin tandem rolling-mill engine, with 42-inch cylinders, and a 74 x 50-inch stroke, designed to operate condensing at 175 pounds steam pressure and a speed of 160 to 200 revolutions per minute. But one engineer will be required to operate this huge engine. Operating the rolls in a steel mill it has to be reversed quickly at the end of each run and the load varies rapidly from nothing to maximum power. The reversing mechanism, which is run by a small independent engine with oil cylinder lock, is of the Reynolds-Marshall type. A second small engine operates the steam throttle valves. The engine was built by the Allis-Chalmers Company, of Milwaukee.

Heat transmission downward into the earth was studied in experiments made recently by the fire department of the city of Hanover, Germany. Three flat piles were made of dry sand, gravel (slightly moist), and building debris; these piles were about 3 feet high, with side slopes of 45 deg. and a square flat top large enough for the erection of a brick furnace. A furnace was built on each pile, 32 inches high, of 5-inch brick walls, with draft openings on opposite sides; the top of the pile of fill formed the floor of the furnace. Coke fires were started in these furnaces and kept up by feeding of coke continued for several days. Fusible cones were used to measure the furnace temperature; they showed 2,200 deg. F. at the base of the fire, but it was concluded that the fire rose over 2,500 deg. F. as the brick walls showed incipient fusion. Thermometers were set in the piles of fill at depths of 4 inches, 12 inches, 20 inches, 30 inches, and 40 inches below the furnace floor. It was found that at the depth of 40 inches only small rise of temperature occurred, even after several days. At 20 inches, the temperature of 160 deg. F., which is about the boiling point for commercial light oils such as benzine, was reached only after the fire had been burning 46 hours. Even at 4 inches depth the temperature remained at 212 deg. F. for a long time, probably from the effect of the water in the material of the fill. The following temperatures were reached in 72 hours in the pile of building debris:

Depth, 4 inches; temperature, 518 deg. F.
Depth, 12 inches; temperature, 185 deg. F.
Depth, 20 inches; temperature, 122 deg. F.
Depth, 30 inches; temperature, 68 deg. F.
Depth, 40 inches; temperature, 63 deg. F.

It was concluded from these tests that relatively small depths of soil protect efficiently against the heat of a fire above, and that tanks containing inflammable liquids are sufficiently protected if their top is at least 20 inches below the ground surface.—Engineering News.

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